AGRICULTURAL RESEARCH INSTITUTE

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# JOURNAL

OF THE

# WASHINGTON ACADEMY

# OF SCIENCES

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*To the Non-resident Members of the Washington Academy of Sciences.*

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METEOROLOGY.—*The amount and vertical distribution of water rapor on clear days.* W. J. HUMPHREYS. To appear in the Bulletin of the Mount Weather Observatory.

It is of especial importance to any one using a bolometer, or a pyrheliometer, to know the approximate amount of water vapor through which the radiation reaching his instrument has passed. With the view of determining average values of this quantity the records of a large number of balloon flights have been examined, and among them 74 found that were obtained on clear days.

These have been grouped according to season, and in each case the average vertical distribution of the water vapor found. In all cases the amount of water vapor rapidly decreases with elevation; but whatever the humidity a first approximation to the average total amount of water vapor above any given level is expressed by the equation,

$$d = 2e,$$

in which $d$ is the thickness in millimeters of the equivalent water layer, and $e$ the partial pressure of the water vapor, at the given level, in millimeters of mercury.

OCEANOGRAPHY.—*The new Coast and Geodetic Survey tide predicting machine.* E. G. FISCHER, Coast and Geodetic Survey. Communicated by O. H. Tittman.

A noteworthy production of the mechanical department of the Coast and Geodetic Survey is the new Tide Predicting Machine. It was completed in February, 1910, and immediately, before polishing, gilding and lacquering, was put in operation for predicting all the complicated tides for the tables of 1912 and

1

1913.   It is now dismounted and being put in a finished state for final installing in the early part of next year.

Six other machines for predicting tides now exist.   The first one, designed and constructed in 1876, by Sir Wm. Thomson, later Lord Kelvin, containing 10 components, was but little used and is now on exhibition in the South Kensington Museum, London.   A second one, with 20 components, was constructed in London for the British India Survey in 1879.   The number of the components was later increased to 24.   It has since been in use for predicting the tides of the British India ports.   The third machine was constructed in 1880, by Sir Wm. Thomson.   It contains 16 components, and it is supposed to be in use for the tides of the British ports.   A copy of this machine was acquired by the French government in 1900 for predicting the French tide tables, and another of the same style was made for the government of Brazil about three years ago.

All these machines produce automatically a tide curve, which must be scaled off for the heights of the high and low waters, their times being taken, in the simpler tides, from hour marks upon the curve.   For exact times a second curve, that representing the first derivative of the height series, must be traced and scaled off.   While it takes only from two to three hours to produce a year's tide curve, several days' work is required to prepare the printer's copy from that curve.

To obtain data required for the printer from the machine direct led Prof. Wm. Ferrel of the Coast and Geodetic Survey, when the need of a tide predictor in that Bureau became imperative, to design one upon principles differing considerably from those of the English machines.   In it the sine terms of the derived or time series are summed simultaneously with those of the cosine or height series, the face of the machine indicating the exact times of high or low water to be copied by the operator upon the form for the printer.   For the simpler tides the heights are also taken from the face by the use of an auxiliary scale, but for the more complicated tides, the machine requires a second setting for the exact heights.   This machine was constructed in 1882 and was used for preparing the tide tables of the Coast and Geo-

detic Survey from that time until 1910. It has 19 components. It produces no curve, but a record of the results is made by blue-printing the printer's copy.

Certain weaknesses and considerable wear made it desirable to provide a new machine, which should indicate upon its face, for copying directly upon the printer's form, the exact heights and times of the high and low waters, of the height of the sea at any time, and produce automatically a tide curve with hour and day marks showing the exact time of the high and low waters. Its construction was begun in 1896 and continued with many interruptions, as time could be spared from the regular work, until its completion in February, 1910.

The principles underlying the machine are the same as those of the English predictors as regards the heights. From the Ferrel machine was adopted the use of two cranks on the same component shaft: one for summing the cosine terms of the height series and the other, at right angles, for summing the sine terms of the first derivative of the former, the latter, when equal to zero, marking the times of the maxima and minima.

In order that the machine should be most comprehensive, provision was made for 37 components. The dimensions of its parts were chosen with particular view to rigidity and freedom from flexure. Workmanship and material are such as to reduce deterioration due to wear to a minimum, and the wearing parts are planned so as to permit of replacement or repair without ever interrupting the regular output of the machine. Its dimensions are: length, 10 feet 9 inches; height, 6 feet 2 inches; and width, 2 feet. The unit of height amplitude is 0.5 inch. The dial unit of height is 1 inch, 2 inches and 4 inches per foot, according to which of three scales is used. The scale of the record curve, traced on paper 6 inches wide, varies between 1:15 and 1:120, the hour being equal to $\frac{1}{2}$ inch, or the day 12 inches.

To predict a year's tides for a station takes one man from $2\frac{1}{2}$ to 4 hours according to the number of components used, for the setting of the machine, and from 8 to 15 hours, according to the complexity of the tides at the station, for copying the indicated results upon the form ready for the printer.

Tests of the machine made under severest conditions, showed agreement between predicted and computed results within 0.06 feet.

OCEANOGRAPHY.—*Note on the composition of sea water·* F. W. CLARKE and GEORGE STEIGER.   Geological Survey.

Although the water of the ocean varies widely in salinity, from less than one per cent in the Baltic to as much as five per cent in the Red Sea, the composition of its saline matter is curiously constant.   Innumerable analyses of it have been made, from the great oceans and the minor seas, so that this conclusion seems to be well established.   Data are so far lacking, however, with regard to the waters of our own coasts, except for a single group of analyses, by A. S. Wheeler, of water from near Beaufort, N. C. In order to remedy this deficiency, Dr. A. G. Mayer of the Tortugas Laboratory of the Carnegie Institution of Washington, kindly collected a sample of water from near Loggerhead Key in the Gulf of Mexico, which was analyzed in the laboratory of the U. S. Geological Survey.   The specific gravity of the water was 1.02434, at 25°, and the total salinity was 3.63516 per cent.   This is slightly above the mean salinity of the ocean, 3.5 per cent.   The percentage composition of the saline matter is given below, in comparison with the average composition of oceanic salts as found by Dittmar for the *Challenger* Expedition.

|                | GULF OF MEXICO | DITTMAR'S AVERAGE |
|----------------|:--------------:|:-----------------:|
| Cl.            | 55 24          | 55.292            |
| Br.            | 0.17           | 0.188             |
| SO₄.           | 7 54           | 7.692             |
| CO₃.           | 0 34           | 0 207             |
| Na.            | 30.80          | 30.593            |
| K.             | 1 10           | 1.106             |
| Ca.            | 1 22           | 1.197             |
| Mg.            | 3.59           | 3 725             |
|                | 100 00         | 100 000           |

The striking similarity of the two columns is evident at a glance. The Dittmar figures are the mean of 77 analyses.

RADIO-TELEGRAPHY.—*High spark frequency in radio-telegraphy.* L. W. AUSTIN. Naval Wireless Telegraphic Laboratory.

In 1908 I published a paper[1] on the subject of the advantages of high spark frequency in radiotelography in cases where integrating detectors were used.[2] In this I called attention first to the great increase in sensitiveness of the telephone with increasing frequency, and second to the advantage to be obtained by distributing the energy of the sending station over a large number of sparks instead of concentrating it in a few. Since that time spark frequencies of approximately one thousand per second have come into common use in radiotelegraphy,[3] but the expected increase in sensitiveness of the telephone at these frequencies has not been obtained. This is illustrated by Table I which contains a comparison of the received energy as measured on a zincite rectifier[4] with galvanometer and the telephone audibility as measured with the same rectifier by the shunted telephone method. The measurements were taken at the Bureau of Standards. From this it is seen that the sensitiveness of the telephone is approximately the same for sixty cycle and five hundred cycle stations. This failure to obtain the increased sensitiveness at the higher frequency is the more remarkable, since, for sine waves at least, it has been shown independently by a number of observers.[5]

We can, however, from the data of Table I determine what the actual current sensitiveness of the telephone under wireless conditions is. We shall assume as a rough average that 1 mm.

[1] Bull. Bur. Standards, **5**: 153. 1908.

[2] Experiments have shown that the electrolytic and most of the rectifying detectors depend only on the energy.

[3] Prof. R. A. Fessenden was already experimenting with high spark frequencies at the time my paper was being written.

[4] Bull. Bureau of Standards, **7**: 295. 1911.

[5] Lord Rayleigh, Phil. Mag. **38**:294. 1894. Wien, M., Ann. d. Phys. **4**:450. 1901. Austin, L. W., loc. cit.

TABLE I

| STATIONS | CYCLES OF GENERATOR | NATURE OF SPARK | DISTANCE, MILES | WAVE LENGTH, METERS | DEFLECTION OF GALVANOMETER D | TELEPHONE AUDIBILITY | DEFLECTION AUDIBILITY |
|---|---|---|---|---|---|---|---|
| | | | | | *mm.* | | |
| *U. S. S Salem* . . | 500 | Fessenden rotary | 120 | 1000 | 100 | 77 | 1 3 |
| Philadelphia Radio. . . | 500 | Quenched | 100 | 2000 | 220 | 150 | 1 45 |
| New York Radio . | 500 | Quenched | 190 | 2200 | 20 | 18 | 1 1 |
| Wilmington . . . | 60 | Old type fixed | 80 | 600 | 65 | 32 | 2 0 |
| Baltimore . | 60 | Old type fixed | 35 | 630 | 130 | 150 | 0 9 |
| Annapolis . | 60 | Old type fixed | 25 | 600 | 70 | 93 | 0 8 |
| *U. S S. Delaware* . . | 500 | Quenched | | 1000 | 7 | 14 | 0 5 |

deflection on the galvanometer corresponds to the least audible sound in the telephone. The sensibility of the galvanometer as used was $1.3 \, 10^{-9}$ amperes per millimeter. In the work with sine waves already cited the telephones then used had a sensitiveness of $3 \times 10^{-10}$ at 900 cycles and $3 \times 10^{-7}$ amperes at 120 cycles. These experiments were made in a perfectly quiet room and experience has shown that the amount of current necessary to distinguish the dots and dashes under ordinary conditions in the laboratory is roughly five times this. We may therefore take the normal sensitiveness of these telephones for receiving purposes as $1.5 . 10^{-9}$ amperes at 900 cycles and $1.5 . 10^{-6}$ at 120 cycles. It is seen that the sensitiveness observed in the case of received signals both at high and low frequencies in Table I corresponds closely to the value obtained with sine waves at 900 cycles. This seems to show conclusively that the higher degree of sensitiveness is obtained with practically all transformer sparks of the types ordinarily used.[6] This might conceivably be explained either by supposing that the sparks in low frequency apparatus

[6] Possibly sparks produced by induction coils with slow moving interrupters or the infrequent sparks produced by certain forms of resonance transformers would show a decreased telephone sensitiveness.

are always multiple, thus producing more or less regular higher tones which make themselves felt in increased telephone sensitibility; or that the short sharp jerks to which the diaphragm is subjected in the case of spark discharges are more effective in moving the diaphragm than sine waves.    These impulses in the case of 1000 sparks per second and a wave length of 1000 meters with 20 waves in the train last about one-seventeenth of the length of time between them if we consider that the duration of the energy is not prolonged in any way ·in the receiving circuit.

Regarding the second advantage of a high spark frequency, namely the distribution of the energy over a large number of sparks instead of concentrating it in a few, experience has amply demonstrated its value.    In tables II and III are given the relation between spark frequency, antenna energy, antenna capacity and current for some commonly used spark frequencies.

One hundred thousand volts is considered to be the maximum which under any circumstances can be used to advantage on an

TABLE  II

ANTENNA  CAPACITY  PER  KILOWATT  OF  ANTENNA  ENERGY

| MAXIMUM ANTENNA POTENTIAL | 1000 SPARKS/SECOND | 120 SPARKS/SECOND |
|---|---|---|
| volts | mf. per kw. | mf. per kw. |
| 50,000 | 0 0008 | 0 0067 |
| 71,000 | 0 0004 | 0 0033 |
| 100,000 | 0 0002 | 0 0017 |

TABLE  III

ENERGY  IN  ANTENNA  OF  0 001  MICROFARADS  CAPACITY  AT  50,000  VOLTS MAXIMUM  POTENTIAL

| SPARKS/SECOND | KILOWATTS | ANTENNA CURRENT* |
|---|---|---|
| | | amp. |
| 120 | 0 15 | 5 |
| 240 | 0 30 | 7 1 |
| 500 | 0 625 | 10 2 |
| 1,000 | 1 25 | 14 3 |

* Antenna resistance assumed to be 6 ohms.

antenna. Unless extraordinary precautions for good insulation are taken about 50,000 seems to be the most advisable limit.

RADIO-TELEGRAPHY. *The slipping contact rectifying detector.* L. W. AUSTIN. Naval Wireless Telegraphic Laboratory.

In 1908 I described[1] a detector for electrical waves in which a bit of tellurium was pressed against an aluminum shaft in rotation. In connection with these experiments, it was found that any slipping contact if sufficiently light gave audible responses in the telephone when connected in the usual position of the detector.

Later experiments showed that this form of detector was very sensitive and extremely simple in use, requiring little adjustment, no stopping condenser and no external E. M. F., full sensitiveness being obtained with the detector simply placed in series with the secondary inductance of the receiving circuit, and a pair of telephones of from 600 to 1000 ohms resistance. The best results have been obtained by the use of a slowly rotating disk of highly polished copper or nickel driven by a spring motor, against which a bit of fine copper wire is lightly pressed.

The one difficulty which has stood in the way of the practical usefulness of this device was the obtaining of a proper surface on which the light sliding point could move, there being a tendency under most circumstances for the point to jump, thus breaking up the signal and making it difficult to distinguish the dashes from the dots. With the introduction of high spark frequency this difficulty has been to a large extent overcome, the wave trains following each other closely enough so that the dashes as heard in the telephone are invariably continuous if the adjustment is correct. When the signals are strong the musical note of the spark is reproduced in the telephone. Unfortunately, however, when they begin to weaken, the irregularities of the contact break up the musical note and it degenerates into a rustling sound which does not serve to distinguish one station from another. In sensitiveness this detector considerably surpasses any of those

[1] Electrical World, **48**: 924. 1906. Phys. Rev., **24**: 509. 1907.

now commonly used, showing itself in various tests to have an energy sensitiveness from three to ten times that of the electrolytic at minimum signal. The response as judged by the shunted telephone method is more nearly proportional to the current than to the current squared as in most other detectors.

The cause of detector action is probably complicated. There is a certain amount of true rectification as shown by a galvanometer connected in place of the telephone. This is not, however, always in the same direction, and the galvanometer sensitiveness is much less than that of the telephone. It is quite possible that the sense of the rectification changes from instant to instant and the galvanometer deflection represents merely the residual in one direction or the other. In addition to the rectifying effects it is probably that the changing contact gives rise to an action similar to that of the Poulser ticker.

RADIO-TELEGRAPHY.—*A preliminary note on the resistance of radio-telegraphic antennas.* L. W. AUSTIN. U. S. Naval Wireless Telegraphic Laboratory.

In the *Physikalische Zeitschrift* for April 15, C. Fischer published an article on the determination of antenna resistance. His method, in brief, is the substitution of an air condenser in place of the antenna and ground keeping the inductance common to both circuits and introducing resistance in the condenser circuit until the current becomes the same as that when the antenna and ground were used. This method, though I am not aware that it has ever before been published, has been in use in America for the measurement of antenna resistance since 1905 or 1906 and was I believe first suggested by R. A. Fessenden.

It has been known in a general way to many experimenters that the antenna resistance was larger at the longer wave lengths than should have been the case according to the Herzian theory of radiation.

In his article Dr. Fischer has given very interesting experimental observations and curves showing that this increase in antenna resistance is under certain circumstances proportional

to the wave length, and he appears to believe that this increased resistance is due to radiation.

Systematic measurements on the resistance of the Bureau of Standards antenna were begun as soon as Dr. Fischer's article appeared. Observations have also been taken on the antenna of the U. S. S. *Dolphin* lying at the Washington Navy Yard and on the antenna of the Navy Yard station.
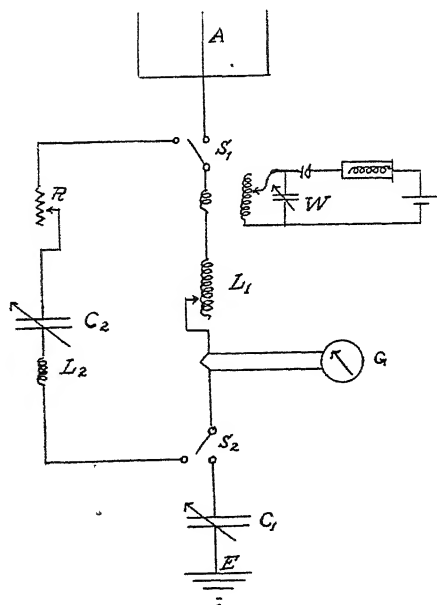


Fig. 1. Diagram of apparatus for measuring antenna resistance

The arrangement of apparatus is shown in Fig. 1. Here $A$ is the antenna, $E$ the ground, $L_1$ the tuning inductance, $C_1$ an air condenser for tuning to very short wave lengths, $Th$ a thermoelement,[1] $G$ a galvanometer and $C_2$ a variable air condenser set at the capacity of the antenna to be measured. A small inductance $L_2$ was sometimes inserted in circuit with the condenser $C_2$ to represent the antenna inductance. This has little influence on

[1] A zincite rectifier with galvanometer very loosely coupled to the circuit may be used instead of the thermoelement.

the results and at least for the longer wave lengths may be perfectly well omitted. $S_1$ and $S_2$ are switches for connecting either the antenna and ground or $C_2$ to the rest of the circuit. $R$ is a resistance introduced in the circuit $C_2$ to bring down the thermo-element deflection to the same value as that observed when the antenna and ground are in circuit. The high frequency resistance consists of separate units of fine constantan wire inserted in mercury cups. The measurement circuit is excited by a buzzer-driven wave meter $W$ of the ordinary type.

Fig. 2 shows the curves obtained on the *Dolphin*, at the Wash-
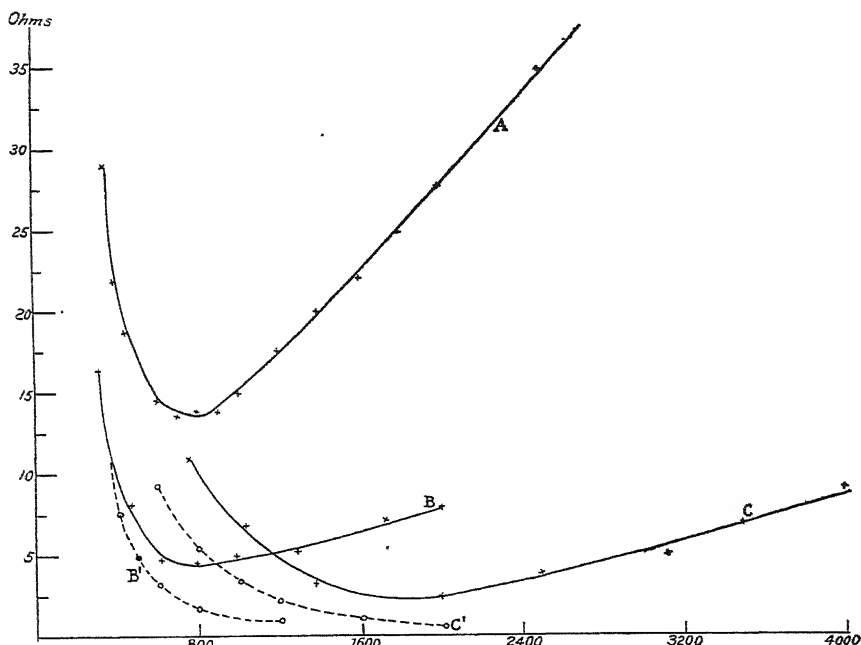


Fig. 2. Diagram showing resistance curves

ington Navy Yard and at the Bureau of Standards. It is seen that beginning with the short wave lengths, the resistance falls rapidly in accordance with the Herzian radiation theory until a point is reached which is not far from twice the fundamental wave length of the antennas.

Curve $A$ is the Bureau of Standards, $B$ the U. S. S. *Dolphin* and $C$ the Washington Navy Yard.   In curves $B$ and $C$ the resistance rises gradually as observed by Fischer but the rise is much slower than in his curves.   The height of the flat-top antenna of the *Dolphin* is approximately 90 feet above the water, while that of the Washington Navy Yard is 150 feet.   The Navy Yard has practically a water ground the station being but a few feet from the river which is moderately salt at this point.   The fundamental of the *Dolphin's* antenna is 315 meters and its capacity is 0.0073 microfarad.   The fundamental of the Navy Yard antenna is about 1000 meters and the capacity is 0.0036.   The radiation resistance for these two antennas calculated according to the equation.[2]

$$R_r = 1600 \, h^2/\lambda^2$$

is shown in the dotted curves $B'$, $C'$.   It is seen that the observed curves for the shorter wave lengths follow with a considerable degree of approximation the curvature of the calculated radiation resistances although the observed curves lie somewhat higher, while beyond the minimum the two curves lie far apart.   We have here an indication of two factors in the resistance; one decreasing as the square of the wave length, while the other increases nearly directly as the wave length.   It seems to me probable that the portion of the resistance which increases as the wave length is ground resistance, or more properly earth current resistance.

The resistance of the Bureau of Standards antenna is shown in curve $A$.   This antenna is an 8-wire harp, 180 feet high at top and 60 feet high at bottom.   This makes the center of capacity 120 feet from the earth.   The natural period is 425 meters and the capacity 0.0012 microfarad.   The ground wires are connected to the water pipes of the laboratory.   It is seen that the minimum ground resistance is much higher than in the case of the *Dolphin* and Navy Yard and that the straight portion of the curve slopes more steeply upward than was the case in the other two antennas measured.   It has been observed that the steepness of

[2] R. Ruedenberg, *Ann. d. Phys.*, **25**: 446.  1908.

this portion of the curve, as well as the resistance at the minimum differs by a very appreciable amount from day to day according to the dryness of the soil. On the day following a heavy rain the minimum frequently falls by two or three ohms, at the same time the resistance at a wave length of 3000 meters sometimes falls as much as ten ohms. The resistances are usually slightly higher in the afternoon than in the morning.

It is a matter of considerable interest to know toward what point the straight portion of the resistance curve descends. According to Fischer it would cross the zero axis near the fundamental, and in the curve of the Washington Navy Yard this also appears to be the case. At the Bureau of Standards, the curve of which has been taken much more accurately than any of our other observations, it appears to point toward the zero of coördinates. This may however be due to the presence of an initial ohmic resistance of about 5.5 ohms in the pipes of the ground connection.

TABLE OF RESISTANCES FOR ANTENNA

| λ | G | $R_r$ | $R_r+G$ | OBSERVED |
|---|---|---|---|---|
| meters | ohms | ohms | ohms | ohms |
| 400 | 5.5 | 13 4 | 18 9 | 22.5 |
| 600 | 8 0 | 5 9 | 13 9 | 15 0 |
| 800 | 11 | 3 4 | 14 4 | 13 6 |
| 1000 | 13 5 | 2 1 | 15 6 | 15 2 |
| 1200 | 16 5 | 1 5 | 18.0 | 17.3 |
| 1500 | 21 0 | 0 95 | 22 0 | 21 0 |
| 2000 | 28 0 | 0 54 | 28 5 | 27.7 |
| 2500 | 34 5 | 0 34 | 34 8 | 34.5 |

In the table under $G$ is given the ground resistance taken from a prolongation of the straight portion of curve $A$. Under $R_r$ is given the calculated radiation resistance, from the Ruedenberg formula, while in the last two columns are given the sum of these resistances and the observed values of the curve. For most of the observations embodied in Fig. 2, I am indebted to my assistants Meneratti and Scanlin, Chief Electricians, U. S. N.

ELECTRICITY.—*Formulas and tables for the calculation of mutual and self inductance.* (Revised.)    E. B. Rosa and F. W. Grover. To appear in the Bulletin of the Bureau of Standards, 8: 1–237.    1911.

With the increase in the precision demanded in electrical measurements, and in the standardization of electrical apparatus, and more especially in the determination of the fundamental units in absolute measure, there has arisen the necessity for more and more precise standards of mutual and self inductance, whose values may be calculated from their dimensions.

For example, in the calibration of working standards of self and mutual inductance, the values are very conveniently referred to those of absolute standards, consisting of windings of bare or enamelled wire wound uniformly on accurately turned forms of marble or other suitable non-magnetic material.    The formulas for the calculation of the constants of such standards from their dimensions should be capable of at least the precision attainable in the measurement of the dimensions of the coil and the pitch of its winding.

In the most accurate methods employed for the absolute measurement of resistance and for the absolute measurement of current by means of a current balance, it is required that the value of a standard of mutual inductance may be calculated to about one part in one hundred thousand.

In magnetic measurements and in wireless telegraphy, a knowledge of the calculated value of a mutual or self-inductance is often requisite, although in these cases a smaller degree of precision is sufficient.

The problem of the calculation of inductance received considerable attention as early as Maxwell's time, with the result that the constants of the simpler forms, such as circles, solenoids, and coils whose cross-section is not too large relatively to the radii, were calculated with fair precision.    Some of these solutions are absolute formulas, involving elliptic integrals; others are expressed as infinite series, the number of terms requisite being governed by the precision desired, and the degree of convergence of the formula for the case in question.

For numerical calculation, the absolute formulas have the disadvantage that the inductance is given by the difference of two nearly equal terms, each of which is many times larger than the desired quantity.   In such cases, each term must be calculated with greater precision than is required in the result.   Series formulas, on the other hand, exhibit a satisfactory degree of convergence over a more or less limited range only, two or more series formulas being, as a rule, necessary to cover the same ground as a single absolute formula.

It thus occurs that several formulas are available in almost every case, and the question naturally presents itself as to what criterion may be applied to aid in the selection of a suitable formula for the solution of a given problem, and which is the more reliable when their results do not agree.

It was to furnish an answer to these questions that Messrs. Rosa and Cohen undertook, in 1906–07, a critical examination of all the existing formulas which had come to their notice.   In the course of this investigation, certain formulas were found to be in error or capable of giving approximate values only, others were extended by them so as to give more accurate results, and in addition many new formulas were derived.   These results appeared in a series of papers in the *Bulletin of the Bureau of Standards*.

At the conclusion of the work, a compilation was made of all those formulas which had been shown to be suitable for numerical calculation, together with auxiliary tables of elliptic integrals and other constants useful in such calculations.   The work was divided into nine sections, treating of the mutual and self inductance of coaxial circles, solenoids, and coils of rectangular cross-section and of linear conductors, together with a chapter on geometric and arithmetic mean distances.   A special feature was a collection of examples so chosen as to provide an illustration of the various formulas, and to show the agreement and relative degree of convergence of the different formulas applicable to the same problem.

Since the appearance of this collection of formulas in 1907, a number of new formulas have appeared, and the edition becom-

ing exhausted, a thorough revision was undertaken.  In the second edition the same general plan and division into sections has been adhered to, with the difference that each example now appears in the section to which it applies.  Considerable new material has been introduced into the sections on the mutual inductance of coaxial circles, the mutual inductance of coaxial solenoids, and the self inductance of solenoids, and a new section has been added, treating of the change of the inductance and resistance of straight cylindrical wires with change in the frequency of the current.

Of the new tables appearing in this edition, may be noted especially Nagaoka's tables for the calculation of the correction which must be applied to the self inductance of a solenoid to take account of the effect of the ends, and the tables for calculating the change of inductance and resistance with the frequency.

A number of new examples have been introduced, in connection with the new formulas, special attention having been given to the agreement of the different formulas and the checking of the results, and to aid in the selection of suitable formulas for any given problem.  A portion of each section has been devoted to a discussion of the points of advantage and range of applicability of each of the formulas therein given.

This collection is intended primarily for work of the highest precision, and the formulas are consequently often more elaborate than will be required in much work of moderate precision.  In such cases the calculation may be considerably simplified by carrying out the values of the various quantities to a smaller number of places of decimals, and by the retention of a smaller number of terms in the series formulas.  The authors have in contemplation the preparation of a collection of approximate formulas for work of less precision.

CHEMISTRY.—*The melting points of the chemical elements.* GEORGE K. BURGESS, Bureau of Standards.

There has been much work done recently in the more exact location of some of these fixed points.  The accompanying

table represents an attempt to assign the most probable values to the several melting points from a consideration of all the data available, and is a revision of the list in the new Smithsonian *Physical Tables*.

In so far as possible, the values are reduced to a common temperature scale, that given by the gas thermometer. In general, differences between the various gas scales as recently determined and the thermodynamic scale are less than the uncertainties of reproducibility by any one method. For example, the four observations on the melting point of gold, by the constant volume nitrogen thermometer, published within the past ten years, range from 1059.3° to 1067.2° C., and the correction to the thermodynamic scale is here 1° or less. Besides the direct gas thermometer determinations, there are, also, for many of the melting points, precise, differential checks made by electrical resistance, thermo-electric, or optical thermometers. The difference between the melting points of gold and copper is thus known to be 20° C. by auxiliary methods more closely than these temperatures have usually been independently located by the gas thermometer.

For the range 100° to 500° C, the scale here adopted agrees with the value 444.7 for the sulphur boiling point, a temperature that has been many times determined, and which is perhaps the best known fixed point above 300°.

For high temperatures, the scale is satisfied very exactly by taking $c_2 = 14,500$ in the formula for Wien's law connecting $I$, monochromatic luminous intensity, and $T$, absolute temperature: $\log I/I_1 = c_2 \lambda \log e (1/T_1 - 1/T)$. This agrees well with the gas thermometer measurements of Day and Sosman in the range 1000° to 1550° C. The use of Wien's law possesses the theoretical advantage for extrapolation beyond 1550° in giving the thermodynamic scale.

In the table, elements whose melting points are well known or used as standards are printed in capitals. An idea of the exactness of our knowledge of some of the melting points is also given.

MELTING POINTS (C) OF THE CHEMICAL ELEMENTS

| ELEMENT | MELTING POINT | REMARKS |
|---|---|---|
| Helium . .. | < −269? | B.P. He = − 268.5<br>Kamerlingh–Onnes |
| Hydrogen . . . ... | −259 | Travers–Jaquerod |
| Neon . . . . . . . . | −253? | |
| Oxygen . . . . . . . . . . | −230? | Range −227 to −235 |
| Fluorine . . . . . . | −223 | Moissan–Dewar |
| Nitrogen . . . . . . . | −210 5 | Fischer–Alt |
| Argon . . . . . . | −188 | Ramsay–Travers |
| Krypton .. . .. . . . . . . | −169 | Ramsay–Travers |
| Xenon . . . . . . . . . . . | −140 | Ramsay–Travers |
| Chlorine . . . . . . . . . | −101 5 | Johnson–McIntosh |
| MERCURY . . . . . . . . . . . . . | −38 7 ± 0 5 | |
| Bromine . . . . . . . . . | −7 3 | Range—7.5 to−7.0 |
| Caesium . . . . . . . . . | 26 | Range 25 3 to 26.5 |
| Gallium . . . . . . . . . . . . | 30 1 | Lecoq-Boisbaudran |
| Rubidium . . . . . . . .. . | 38 | Range 37.8 to 38.5 |
| Phosphorus. . . . . . . . . . | 44 1 | Hulett |
| POTASSIUM . . . . . . . . . . | 62 3±0 2 | |
| Sodium . . . . . . . . . . . . | 97 5±1 0 | |
| Iodine . . . . . . . . . . . . . . | 114±1 | |
| Sulphur . . . . . . . . . . . . | 113.5 to 119 5 | Various forms |
| Indium . . . . . . . . . . . . . . | 154.5±0 5 | |
| Lithium . . . . . . . . . . . . | 186 | Kahlbaum |
| Selenium . . . . . . . . . . | 217 to 220 | Various forms. Saunders |
| TIN. .. . . . . . . . . . . . . . | 231 9±0 2 | |
| Bismuth . . . . . . . . . . . | 270 | Range 267.5 to 271.5 |
| Thallium . . . . . . . . . | 302±1 | |
| CADMIUM . . . . . . . . . . . | 321 0±0 2 | Range 320 0 to 321.7 |
| LEAD . . . . . . . . . . . . . . | 327.4±0 4 | |
| ZINC . . . . . . . . . . . . . . . | 419 3±0 3 | Range 418.2 to 419.4 |
| Tellurium . . . . . . . . . . . . | 451±1 | |
| Arsenic . . . . . . . . . . . . | 500 | Guntz–Broniewski |
| ANTIMONY . . . . . . . . . . . . | 630±1 | "Kahlbaum" purity only |
| Cerium . . . . . . . . . . . . . . | 645? | |
| Magnesium . . . . . . . . . . . | 650±2 | |
| ALUMINIUM . . . . . . . . | 658±1 | |
| Calcium . . . . . . . . . . . . | 805±5 | |
| Lanthanum . . . . . . . . . . | 810? | Muthmann-Weiss |
| Strontium . . . . . . . . . . | >Ca,<Ba? | |

MELTING POINTS (C) OF THE CHEMICAL ELEMENTS

| ELEMENT | MELTING POINT | REMARKS |
|---|---|---|
| Neodymium . . . . . | 840? | Muthmann–Weiss |
| Barium . . | 850 | Guntz |
| Germanium . . . . . | <Ag | Winkler |
| Praescodymium . . | 940? | Muthmann–Weiss |
| SILVER . . . . . | 961 ≐2 | |
| Radium . . . | 600 to 1200? | Unknown |
| GOLD. .. . . . . . | 1063 ≐3 | |
| COPPER . . | 1083 ≐3 | |
| Manganese.... . ..... | 1225 ≐15 | |
| Yttrium. . . . . | 1000 to 1400? | Unknown |
| Samarium . . . . | 1300 to 1400 | Muthmann–Weiss |
| Scandium. .. . . | 1000 to 1400? | Unknown |
| Silicon.. . . . . . | 1420 ≐15 | |
| NICKEL . . . . | 1450 ≐10 | Day–Sosman = 1452 |
| Cobalt. .. . . . . | 1490 | Day–Sosman |
| Chromium.. . . . . | 1505 ≐15 | |
| IRON.. .... . . . | 1520 ≐15 | |
| PALLADIUM. . . . . | 1550 ≐15 | Day–Sosman = 1549 |
| Zirconium. . | > Silicon | Troost |
| Thorium . . . | >1700, < Pt | Wartenberg |
| Vanadium | 1730 ≐30 | |
| PLATINUM.. .. . | 1755 ≐20 | Waidner–Burgess = 1753 |
| Beryllium . . . | >1800 | Parsons |
| Ytterbium . . | 1600 to 2000? | Unknown |
| Titanium . . . . | 2200 to 2400? | Weiss–Kaiser |
| | 1800 to 1850 | Hunter |
| Rhodium. . . . | 1920? | Range 1907 to 1970 |
| Ruthenium . | >1950 | Joly |
| Niobium.. .... . . . | 2200? | v. Bolton = 1950 |
| Boron.... . . . . ... | 2200 to 2500 | Weintraub |
| Iridium. .. . . . . . | 2300? | Range 2100 to 2350 |
| Uranium. ... .. .. | near Mo | Moissan |
| Molybdenum. . . | 2500? | Range 2110 to > 2500 |
| Osmium.. .. .. . . . | 2700? | Waidner–Burgess |
| Tantalum . . ... .. | 2900 | Waidner–Burgess |
| TUNGSTEN . . ..... . | 3000 ≐100 | $\Big\{$ Range 2575 to 3250 <br> Waidner–Burgess = 3080 |
| Carbon . . .... . ... | ? | Unknown |

ELECTRO-CHEMISTRY.—*Thermodynamics of concentration cells.* HENRY S. CARHART. Communicated by E. B. Rosa. To appear in the Bulletin of the Bureau of Standards.

The equation $A = H + \dfrac{dA}{dT}$ may be considered as a very general expression of the laws of thermodynamics for isothermal processes. For the E. M. F. of a voltaic cell, this may be put in the more specific form of the Helmholtz equation $E = \dfrac{H}{nF} + T\dfrac{dE}{dT}$.

We may emphasize the two following cases: *first*, when $H$, the change in internal energy, is a constant. $dA/dT$ or $dE/dT$ is then zero, and the relation between $A$ or $E$ and the absolute temperature $T$ is linear; *second*, an examination of Nernst's expressions for $A$ and $H$ in terms of the integral powers of $T$. These are according to Nernst

$$A = A_0 - bT^2 - \tfrac{1}{2}cT^3 - . \quad . \quad .$$
$$H = H_0 + bT^2 + cT^3 + . \quad . \quad .$$

Nernst makes the coefficient of the first power of $T$ in the expression for $A$ necessarily equal to zero. It is easily shown, however, that this coefficient is not zero from a mathematical point of view.

We have made an experimental investigation of the E. M. F. of various concentration cells with amalgams of different concentration as the electrodes. In every case a linear relation is established between the E. M. F. and temperature. The expression for the $E$ then has the form $E = E_h + aT$, where $E_h$ is the E. M. F. due to the internal change of energy $H$. The coefficient $a$ is not zero as Nernst assumed it to be.

For the zinc amalgams used the equation expressing the E. M. F. is          $E = -0.001455 + 0.00003084T$
and the following table shows how nearly the E. M. F. as computed from this equation correspond with the observed ones:

| TEMPERATURE | OBS. E.M.F. | COMP. E.M.F. | PER CENT DIFFERENCE |
|---|---|---|---|
| 11 1° | 0 007300 | 0 007307 | +0.10 |
| 15 4 | 0 007444 | 0 007439 | −0 07 |
| 19.8 | 0 007574 | 0 007575 | +0 01 |
| 24.6 | 0 007720 | 0 007723 | +0 04 |
| 29 4 | 0 007870 | 0.007871 | +0 01 |
| 32 8 | 0 007983 | 0.007976 | −0 09 |
| 36 6 | 0 008086 | 0 008094 | +0 10 |
| 42 0 | 0 008262 | 0 008259 | −0.04 |
| 47 0 | 0 008417 | 0 008414 | −0 04 |

Electrolytic thermoelectromotive forces were measured also and showed a linear relation over a range of temperatures as much as 25 or 30°.

We have constructed two calomel cells, one with a positive temperature coefficient and the other with an equal negative one. The two cells are identical except that the former is set up with a 10 per cent zinc amalgam, and the latter with one of about 0.8 per cent. When the two cells are joined in series, the sum of their electromotive forces is independent of temperature through at least the range 8° to 34° C.

INORGANIC CHEMISTRY.—*The Fractional Precipitation of Carbonates.* ROGER C. WELLS. Geological Survey. Communicated by F. W. Clarke.

In a recent paper I described experiments upon the fractional precipitation of sulphides and pointed out that the results were in accord with what would be expected from our knowledge of the solubilities of the sulphides in water.[1] In the experiments with the sulphides fractionations were carried out with mixtures of two metallic salts in various proportions. Similar experiments are now being conducted with carbonates. Some preliminary results are presented here for mixtures containing equivalent quantities of each metallic salt. Full data and discussion are reserved for a later paper.

The procedure in these experiments was simple. A dilute solution containing two metallic salts in equivalent quantities was

[1] Econ. Geol. 5; 1. 1911.

precipitated by sodium carbonate enough for one metal only. After a time an aliquot portion of the mother liquor was analyzed and thus the composition of the precipitate determined by difference.

Since the experiments were intended to apply to the chemistry of ore deposition it was desired to find out the *final* effect. It was shown by some of the earlier results that the immediate action consists in a precipitation of both metals in nearly equivalent quantities, and that one of them proceeds to dissolve, the other

TABLE I

FRACTIONAL PRECIPITATIONS

| EXPERIMENT | TAKEN, MILLI-EQ. PER LITER | | DURATION OF EXPERIMENT | FOUND IN PRECIPITATE | |
|---|---|---|---|---|---|
| | | | *days* | | |
| 4. . . | 8 $ZnSO_4$ | 8 $CaSO_4$ | 17 | 6.52 Zn | tr. Ca |
| 5.. . | 20 $CdSO_4$ | 20 $ZnSO_4$ | 19 | 15 5 Cd | 4 5 Zn |
| 6 . . . | 10 $FeSO_4$ | 10 $CaSO_4$ | 3 | 6.25 Fe | tr. Ca |
| 7.. .. .. | 10 $CuSO_4$ | 10 $FeSO_4$ | 2 | 5.30 Cu | 5.35 Fe |
| 8. . . . | 8 $CuSO_4$ | 8 $ZnSO_4$ | 26 | 6.84 Cu | 0.76 Zn |
| 22.. .. .. | 8 $Pb(NO_3)_2$ | 8 $AgNO_3$ | 4 | 8.00 Pb | 0 08 Ag |
| 23.. .. .. | 8 $Pb(NO_3)_2$ | 8 $Cd(NO_3)_2$ | 6 | 8.00 Pb | 0.42 Cd |
| 24. ... | 8 $Zn(NO_{3/2})$ | 8 $Pb(NO_3)_2$ | 6 | 7.96 Pb | tr. Zn |
| 25 . | 8 $AgNO_3$ | 8 $HgNO_3$ | 24 | 2 28 Ag | 7.98 Hg |
| 26. . | 8 $AgNO_3$ | 8 $Cd(NO_3)_2$ | 4 | 0.30 Ag | 7.18 Cd |
| 27. . . .. | 8 $ZnSO_4$ | 8 $NiSO_4$ | 10 | 5.00 Zn | 1 50 Ni |
| 28..... ... | 8 $AgNO_3$ | 8 $Zn(NO_3)_2$ | 8 | 1 60 Ag | 3.96 Zn |
| 29.. . ... | 8 $FeSO_4$ | 8 $NiSO_4$ | 1 | 4.20 Fe | 3 06 Ni |
| 30. .... | 8 $FeSO_4$ | 8 $Zn(NO_3)_2$ | 1 | 2.66 Fe | 2.64 Zn |
| 31. ... | 8 $Cd(NO_3)_2$ | 8 $HgNO_3$ | 11 | 3 54 Cd | 7 36 Hg |
| 32........ | 8 $MnSO_4$ | 8 $CaSO_4$ | 2 | 6.56 Mn | 1.64 Ca |
| 33. .. ... | 8 $NiSO_4$ | 14 54 $MgSO_4$ | 5 | 5 94 Ni | tr. Mg |
| 34........ | 8 $NiSO_4$ | 8 $MnSO_4$ | 9 | 4 04 Ni | 3.80 Mn |
| 39........ | 8 $AgNO_3$ | 8 $MnSO_4$ | 7 | 3 98 Ni | 5.76 Mn |
| 40. ...... | | | | | |
| 41.... .... | 8 $AgNO_3$ | 8 $CaSO4$ | 7 | 6 80 Ag | 1 56 Ca |
| 42..... . . | 8 $CaSO_4$ | 8 $MgSO_4$ | 8 | 1 60 Ca | 1 12 Mg |
| 60. .... . | 8 $CuSO_4$ | 8 $CdSO_4$ | 8 | 7 24 Cu | 0 20 Cd |
| 64... ... | 8 $NiSO_4$ | 8 $AgNO_3$ | 6 | 3 16 Ni | 2.96 Ag |
| 71.... ... | 16 $ZnSO_4$ | 16 $MnSO_4$ | 18 hrs. | 11.96 Zn | 8 96 Mn |
| 74. ... . | 16 $MnSO_4$ | 16 $CaSO_4$ | 1 hr. | 14.80 Mn | 5 70 Ca |
| 78..... .. | 8 $ZnSO_4$ | 8 $CdSO_4$ | 15 | 1.26 Zn | 2.34 Cd |

## TABLE II

### Precipitation Series and Relative Precipitations

| EXPERIMENT | MAJOR CONSTITUENT OF PRECIPITATE | MINOR CONSTITUENT OF PRECIPITATE | RATIO OF MAJOR TO MINOR CONSTITUENT |
|---|---|---|---|
| 55 . . . . | Hg | Pb | Large |
| 31 . . . . . . . . | Hg | Cd | 2.1 |
| 25 . . | Hg | Ag | 3 5 |
| 59. . . . . . . | Pb | Cu | Large |
| 23. . . . . . . . . | Pb | Cd | 19 0 |
| 24 . . . . . . . . . . . . | Pb | Zn | Large |
| 22.. . . . | Pb | Ag | 100 |
| 7... . . . . . . . . . | Cu | Fe | 1.0 |
| 8 . . . . . . . . . . | Cu | · Zn | 9 0 |
| 60 .. . . . . . . | Cu | Cd | 36.0 |
| 78 .. . . . . . . . . . . . | Cd | Zn | 1 9 |
| 67 . . . . . . . . . | Cd | Ni | 2.8 |
| 26. . . . . . . . . | Cd | Ag | 25 0 |
| 28 . . . . . . . . . | Zn | Ag | 2.5 |
| 27 . . . . . . . | Zn | Ni | 3.3 |
| 4 . . . . . | Zn | Ca | 6 5 |
| 71 . . . | Zn | Mn | 1.3 |
| 7 . . . . . . . . | Fe | Cu | 1.0 |
| 30.. . . . . . . | Fe | Zn | 1 0 |
| 29. . . . . . . . . | Fe | Ni. | 1.4 |
| 6 .. . . . . . . . . | Fe | Ca | 6 3 |
| 34.. . . . . . . . . | Ni | Mn | 1 1 |
| 33... . . . . . . . . | Ni | Mg | Large |
| 64 . . . . . . . . . | Ni | Ag | 1 1 |
| 32, 74 . . . . . | Mn | Ca | 4 0 |
| 41 . . . . . | Ag | Ca | 4.4 |
| 42 . . . . . . . . . | Ca | Mg | 1.4 |

to precipitate, with the lapse of time. The change goes on for several days at the ordinary temperature, accompanied by a gradual transformation of the precipitate from a flocculent to a

more or less crystalline state.   The bottles containing the solution
and precipitates were allowed to stand as long as desired, with
occasional shaking, in the laboratory at about 20°.   There is no
doubt that some of the precipitates were basic but this would
make no difference as far as the application to geochemistry is
concerned, for, many such salts are well known as minerals.

In the results below the concentrations are expressed in milli-
equivalents per liter, an equivalent being equal in grams to the
molecular weight of the metal or radicle reduced to a univalent
basis.   Where a liter of solution was not employed the results
have been calculated to that dilution.   The amount of sodium
carbonate used was sufficient to precipitate all of one metal only.
The results are given in Table I.

When the results in Table I are considered it is seen that in
general the separation is not complete.   The metals may be
arranged in a series, however, such that the first one is precipi-
tated to a greater extent than the next and so on.   The complete-
ness of the fractionation is greater as the metals are more widely
separated in the series, as is shown in Table II.   In some cases
special reactions occur as, for example, the reduction of silver
salts by ferrous and manganous salts, and these experiments are
omitted.

Altho it is incorrect to state that the series represents the order
of solubility of the carbonates it does represent the order of the
precipitating power of carbonates upon metallic salts under simi-
lar conditions.   The order is Hg, Pb, Cu, Cd, Zn, Fe, Ni, Mn,
Ag, Ca, Mg.   The most striking fact, perhaps, is the position of
silver which is found between manganese and calcium.

The effect of bicarbonates and of higher temperatures is under
investigation.

MINERALOGY.—*Ferritungstite, a new mineral.*  WALDEMAR T.
    SCHALLER.   Geological Survey.   To appear in the American
    Journal of Science.

The new mineral *ferritungstite* is a hydrous ferric tungstate
formed by the oxidation of wolframite, with which it occurs in
pure and crystalline form as minute hexagonal scales, in the Ger-

mania Tungsten Mine, Washington. The yellow to brownish-yellow mineral is decomposed by acids, yellow oxide of tungsten separating out.

Analyses of two samples from the same specimen gave:

|  | 1 | 2 | RATIOS | |
|---|---|---|---|---|
|  |  |  | 1 | 2 |
| $WO_3$ . | 37 1 | 35.8 | .94 | 88 |
| $Fe_2O_3$ .. . | 26.6 | 27.3 | 1.00 | 1.00 |
| $H_2O$ (Ign.) ... | 18 6 | 20 9 | 6 06 | 6 82 |
| Insoluble .. | 14 7 | [16.0] |  |  |
|  | 97.0 | 100 0 |  |  |

The formula deduced is $Fe_2O_3$. $WO_3$. $6H_2O$.

MINERALOGY—*Hinsdalite, a new mineral.* E. S. LARSEN and W. T. SCHALLER. Geological Survey. To appear in the American Journal of Science.

*Hinsdalite* was first collected (by E. S. L.) from the dump at the mouth of one of the tunnels of the Golden Fleece mine, near Lake City, Hinsdale County, Colorado where it is abundant as an original vein mineral associated with quartz and a little pyrite, galena, tetrahedrite, and barite. It occurs in bands an inch or so across and as crystals imbedded in granular quartz.

The crystals are either rhombohedrons, resembling cubes, or pseudo-hexagonal tablets. The angle $rr'$ is about 91.3° from which the value 1.268 is calculated for the $c$ axis. If the apparent hexagonal base be taken as the true base, there is a perfect basal cleavage, but the cleavage faces are nearly all wavy and striated. The optical data indicate that the mineral is only pseudo-hexagonal. The hardness is about 5; the luster is vitreous to greasy. The fresh mineral is pale greenish, but much of the material is dark grey from inclusions. The streak is colorless.

The indices of refraction are somewhat variable but the values for the principal zones are about $a = 1.670$, $\beta = 1.671$, $\gamma = 1.688$. Sections normal to the cleavage show parallel extinction, while those parallel to the cleavage are in many cases hexagonal in

outline and show the emergence of the positive acute bisectrix. They may easily be taken for uniaxial crystals, as the axial angle is small but variable.    2E is usually about 32°.    Basal sections of some of the crystals are divided into six radial segments and the plane of the optic axis in each segment is normal to the pseudo-hexagonal prism edge.

The following analysis was made on fresh, light gray crystals of *hinsdalite*.    They were examined microscopically and found to be very pure but showed a slight zonal growth.

<div align="center">

*Analysis of hinsdalite*

W   T. Schaller, analyst

</div>

| | | |
|---|---|---|
| PbO . | 31.75 ⎫ | 1 93 or 2 |
| SrO . | 3.11 ⎭ | |
| Al$_2$O$_3$ | 26 47 | 2.92 or 3 |
| SO$_3$. | 14.13 | 1 99 or 2 |
| P$_2$O$_5$ | 14 50 | 1 14 or 1 |
| H$_2$O . | 10 25 | 6 40 or 6 |

CaO, MgO, Na$_2$O, K$_2$O traces.    Density = 3.64.

Formula 2 (Pb, Sr) $0.3Al_2O_3.P_2O_5,2SO_3.6H_2O$.

Hinsdalite is infusible but whitens on heating.    It reacts for aluminum when heated with cobalt nitrate, and readily yields a button of metallic lead.    The water is driven off only at a temperature of from about 400° to 600° C.    It is insoluble in acids. From its chemical composition and crystallographical form it is seen to be closely related to svanbergite and forms an additional member of the alunite-beudantite group.

MINERALOGY.—*Beaverite, a new mineral.*    B. S. BUTLER and
     W. T. SCHALLER.    Geological Survey.    To appear in the
     American Journal of Science.

The new mineral *beaverite*, a hydrous sulphate of copper, lead, and ferric iron, was found (by B. S. B.) in the Horn Silver mine near Frisco, Beaver County, Utah.    The mineralization occurs along a fault that has thrown Tertiary lavas down against Cambro-Ordovician limestone.    The ore is mainly a replacement of the volcanic rocks.

The principal primary minerals of the deposit are galena,

sphalerite, wurtzite, pyrite, chalcopyrite, jamesonite (?), pyrargyrite, argentite, quartz, barite, sericite, and small amounts of other minerals.

To a depth of about 600 feet the primary minerals have been almost entirely altered by descending solutions and this alteration has taken place to a lesser extent to a much greater depth. The characteristic alteration is to sulphates with some secondary carbonates, chlorides, and sulphides.

The following secondary minerals have been recognized: Anglesite, cerusite plumbojarosite, jarosite, *beaverite*, linarite, bindheimite (?), smithsonite, calamine, goslarite, covellite, chalcocite, brochantite, malachite, azurite, chrysocolla, chalcanthite, cerargyrite, sulphur, chalcedony, kaolinite, gypsum, hydrous oxide of iron and manganese, and alunite (?).

Beaverite commonly occurs mixed with other secondary minerals but occasionally is found pure in small, friable masses. It is canary yellow in color and crystallizes in six-sided plates too small for measurement of the angle or determination of the optical character. Minute inclusions, whose character has not been determined, are present in nearly every crystal.

The mineral is soluble in boiling hydrochloric acid leaving an insoluble silicious residue. The analysis and ratios are as follows:

### Analysis of beaverite
#### W. T. Schaller, analyst

| | | | |
|---|---|---|---|
| Insoluble | 10.05 | | |
| CuO | 9.70 | 0 121 | 92 or 1 |
| PbO. | 29 44 | 0 132 | 1 00 or 1 |
| $Fe_2O_3$. | 17 28 | 0 108⎱ 144 | 1.07 or 1 |
| $Al_2O_3$ | 3.64 | 0 036⎰ | |
| $SO_3$ | 21 32 | 0 266 | 2 01 or 2 |
| $H_2O$ | 9 02 | 0 501 | 3 80 or 4 |
| | 100 45 | | |

The ratios agree well with the formula $CuO.PbO.Fe_2O_3.2SO_3.4H_2O$. The water is all constitutional as none was driven off below 250°. There is no known mineral to which beaverite is related so that at present it stands as an isolated member of the sulphate group.

# ABSTRACTS

METEOROLOGY.—*Free air data at Mount Weather for October, November, and December, 1910.* Bulletin of the Mount Weather Observatory, 3: 304–346. 1911.

During this period of 92 days, 85 kite and 7 captive balloon ascensions were made at Mount Weather, Virginia. The average height attained was 3115 meters above sea-level. The temperature, relative humidity, direction and velocity of the wind were all obtained at numerous levels and are given both in tabular form for each flight and graphically for each half month. W. J. HUMPHREYS.

METEOROLOGY.—*Temperature departures, monthly and annual, in the United States, January, 1873, to June, 1909, inclusive.* Bulletin U. S. Weather Bureau. 1911.

The 474 separate charts of this bulletin show the departure from the normal of the mean monthly and mean annual temperatures of the United States for the period, January 1873, to June 1909, inclusive, one for each month and one for each year.

Beginning with the issue for July, 1909, similar charts have appeared in each number of the Monthly Weather Review, so that the series is now complete from January, 1873, to date. W. J. HUMPHREYS.

METEOROLOGY.—*Frost data of the United States; and length of the crop-growing season.* P. C. DAY. Bulletin U. S. Weather Bureau No. 5. 1911.

This bulletin consists essentially of five large charts that show, graphically, certain climatological data of vital importance, namely: (1) The average date of the last killing frost in spring. (2) The average date of the first killing frost in autumn. (3) The latest date on which

a killing frost has occurred in spring. (4) The earliest date on which a killing frost has occurred in autumn. (5) The average length of the crop growing season, or the number of days between the average date of the last killing frost in spring and the first killing frost in autumn.

The data consist of the 10 to 30 year records of about one thousand country stations, and, therefore, being free from city disturbances, are of especial climatological value.                    W. J. HUMPHREYS.

METEOROLOGY.—*The Aleutian and Icelandic lows.* W. J. HUM-
PHREYS. Bulletin of the Mount Weather Observatory, 4. 1911.

The high regions of Greenland and Iceland are perpetually ice covered and perpetually cold. Hence at their level the air is, in general, warmer over the intervening ocean than over the land. There must therefore exist a nearly continuous atmospheric overflow from above the ocean onto these two land areas and a drainage in turn of the air from them to the water. But this is the nature of a cyclonic circulation, and therefore this region is almost continuously surrounded by counterclockwise winds of varying intensity.

A similar temperature distribution, with its resulting cyclonic winds, obtains during the winter in the neighborhood of the Aleutian islands. But the Siberian and Alaskan peninsulas, since their elevation is small, are relatively warm in summer and hence the Aleutian low is only a seasonal phemonenon.

With the exception of the polar regions, in contrast with the equatorial, there are no other places with such pronounced and, at the same time, so continuous temperature gradients to either side of them, and therefore no other permanent or semipermanent low.                    W. J. H.

METEOROLOGY.—*Vertical temperature gradients and convection limits.* W. J. HUMPHREYS. Bulletin of the Mount Weather Observatory, 4. 1911.

By day the surface layer of the air is warmed mainly by contact with the heated earth, and the layers next above by convection. Hence the afternoon temperature gradient must closely follow first, the dry air adiabat, and then, if convection has extended high enough, the saturation adiabat.

By night the lowest air is cooled by contact with the relatively cold earth, and the layers next above partly through mixture with the cooler under air and partly by radiation, and thus an inversion gradient—one that shows warming with elevation—is often produced near the surface.

Hence the average gradient departs more and more from the adiabats as the surface is approached. These deductions are fully supported by the temperature records of sounding balloons.

Morning convections, therefore, necessarily are shallow, since the dynamic cooling of the rising air quickly brings its temperature to or below that of the surrounding atmosphere. The same conditions also limit the height of the afternoon convections, though these generally attain to greater elevations than do those of the forenoon. W.J.H.

METEOROLOGY.—*Some weather proverbs and their justification.* W. J. HUMPHREYS, Weather Bureau. Popular Science Monthly, 78: 428–444. 1911.

A large number of weather proverbs dealing with the colors of the sky, haloes, coronas, clouds and other natural phenomena are given, and both their causes and relation to weather changes explained in non-technical terms.

Only those proverbs are quoted that concern natural phenomena and which have more or less scientific justification for the predictions they make.                                                  W. J. H.

OCEANOGRAPHY.—*Arctic tides.* ROLLIN A. HARRIS. 103 pp. 2 figs. and map. Government Printing Office. 1911.

In preparing this paper, which gives in detail the observations by the Peary expedition, 1908–1909, and by the expedition under Mikkelsen and Leffingwell, 1906–1907, one of the principal aims has been to bring together all available results pertaining to tides in Arctic waters. Scientifically, the most important of these is probably the table of harmonic constants for 50 stations, all but one of which lie north of the 60th parallel. The lunitidal intervals and ranges of tide are given for more than 200 points or stations in the Arctic Regions. The mean range of tide varies from 23 feet in Ashe Inlet, Hudson Strait, to 0.2 foot at Pitlekaj, on the Siberian coast not far west of Bering Strait.

A cotidal map shows the times and ranges of the semidaily tide, so far as known, and the estimated times in regions where no observations have been taken. The semidaily tides of the Arctic Ocean are derived almost entirely from those of the Atlantic; for, the semidaily tidal forces are small in high latitudes and vanish at the Pole. Hence the extensive progressions from the Atlantic into and over the Arctic. Five "no-tide points," or points where the range of the semidaily tide becomes zero, are indicated upon the map.

The tides in Baffin Bay and in Robeson Channel consist largely of stationary waves.

One of the most remarkable results established by the Peary expedition is that the semidaily tide wave progresses eastward, and not westward, along the northern coast of Grant Land, which shows that the progressive wave from Lancaster Sound and Jones Sound, which passes west of Axel Heiberg Island, governs this tide.

The fact that the range of tide coming from the west can be as large as 0.8 foot at Point Aldrich, near Cape Columbia, indicates that land is not far distant towards the northwest.

In high latitudes the diurnal forces are large; and so if there exist a deep uninterrupted polar ocean, the diurnal tide should approximately follow the equilibrium theory for an inclosed sea. For certain arctic coasts this is the case while for others either the times or ranges depart considerably from the theoretical values.

Some of the facts tending to establish the existence of land situated between the Arctic Archipelago and the Arctic coast of eastern Siberia are as follows: (1) At Point Barrow the flood comes from the west and not from the north; (2) the range of the semidaily tide at Bennett Island is 2.5 feet while it is only 0.4 foot at Point Barrow and 0.5 foot at Flaxman Island; (3) the times of the semidaily tide on the north coast of Alaska do not indicate that the tide, propagated from the Atlantic Ocean to Alaska, crosses a deep and uninterrupted polar basin; (4) the diurnal tides at Teplitz Bay, Bennet Island, Pitlekaj, Point Barrow, and Flaxman Island have less than one half of their equilibrium values, which fact makes the supposition of an uninterrupted polar basin improbable if not impossible; (5) the westward drift of the Jeannette and the westward drift observed by Mikkelsen and Leffingwell indicate an obstruction in the polar basin.          R. A. H.

TERRESTRIAL MAGNETISM.—*Directions for magnetic measurements.* D. L. Hazard. Pp. 131. Government Printing Office. 1911.

This publication aims to present the subject so that an observer familiar with the use of instruments but without experience in magnetic work may make observations for determining magnetic elements without other assistance than the book itself. The first part is devoted to definitions, explanations of principles, and the derivation of formulas. The three other sections of the book give specific directions for absolute observations on land and at sea and general directions for the operation of a magnetic observatory. At the end of the volume are standard forms of record and tables for use in computation. The volume can be easily carried in the field.          R. L. Faris.

TERRESTRIAL MAGNETISM.—*Results of observations made at the Coast and Geodetic Survey Magnetic Observatory at Cheltenham, Md., 1907 and 1908.* D. L. HAZARD. Washington, Government Printing Office, 1911. *Results of observations made at the Coast and Geodetic Survey Magnetic Observatory at Sitka, Alaska, 1907 and 1908.* D. L. HAZARD. Washington, Government Printing Office, 1911. *Results of observations made at the Coast and Geodetic Survey Magnetic Observatory near Honolulu, Hawaii, 1907 and 1908.* D. L. HAZARD. Washington, Government Printing Office, 1911.

In terrestrial magnetism the Coast and Geodetic Survey has published during this calendar year, the results of its magnetic observatory work at three of its five magnetic observatories for the years 1907 and 1908, viz: for Cheltenham, Maryland; Sitka, Alaska; and Honolulu, Hawaii. Each volume contains the results of two years observations. The hourly values of the magnetic declination, the horizontal and vertical magnetic intensity are tabulated for the whole period. The mean nourly values of these magnetic elements are given for each month as well as those for the "ten least disturbed days." Based upon the data in these tables are other tables showing the diurnal variation of the magnetic elements. A summary of monthly mean values of the different magnetic elements is also given.

The volumes also contain tabulations of the principal magnetic disturbances recorded at the observatories. The actual records of a number of these magnetic disturbances or "magnetic storms" are reproduced to three-fourths the original size, and are referred to Greenwich mean time for facility of comparison with the records of other observatories.

The magnetic data conform as far as possible with the recommendations of the Commission on Terrestrial Magnetism of the International Meteorological Committee as expressed at its several meetings since 1896.

In these volumes is also given the data of all earthquakes recorded on the seismographs operated at the magnetic observatories during 1907 and 1908.

At the present time all of the magnetic observatories of the Coast and Geodetic Survery are making special registration observations of the magnetic elements. (declination, horizontal and vertical intensity) at stated periods, in response to the request of the Royal Society of London for international coöperation in magnetic work on certain term days from May, 1911, to January, 1912, covering a portion of the period of the magnetic work of the English South Polar Expedition now in the antarctic regions.

During the month of April special simultaneous registration observations were made at Cheltenham, Maryland, and at Tucson, Arizona, in coöperation with the magnetic work of Professor Birkeland at Khartum, Africa, when studying the zodiacal light. It was thought that the comparison of the magnetic curves at places so far apart might serve to decide the question of the simultaneity or non-simultaneity of the abruptly beginning magnetic storms.                    R. L. FARIS.

PHYSICS.—*On the computation of the constant $c_2$ of Planck's equation by an extension of Paschen's method of equal ordinates.* E. BUCKINGHAM and J. H. DELLINGER. Bulletin Bureau of Standards, 7: 393–406, 1911.

Planck's equation for the intensity of radiation $J$, of wave length $\lambda$, from a black body at the absolute temperature $\theta$ viz.

$$J = C_1 \left[ \lambda^5 \left( e^{c_2/\lambda\theta} - 1 \right) \right]^{-1}$$

appears to represent very well the results of all known observations. If $\lambda\theta$ is not too large, the experimental facts are represented sufficiently well by Wien's equation:

$$J = C_1 \lambda^{-5} e^{-c_2/\lambda\theta}$$

This equation defines an optical scale of temperature, which is used for high temperature work. To make this scale fit the standard gas scale of temperature within their common range of about 650° C. to 1650° C., the constant $c_2$ must be known accurately. This constant may be determined by observing the distribution of energy in the spectrum of a black body at a constant temperature, giving a so-called "energy curve." From the two values of $\lambda$ corresponding to equal values of $J$ on either side of the maximum of the curve, $c_2$ may be calculated by an equation due to Paschen provided the observed curve is representable by Wien's equation.

This paper extends Paschen's method, in two different ways, to apply to curves for which Planck's equation must be used. The first method consists in the substitution in Paschen's equation of corrected values of the wave lengths read from the energy curve, the point of the method being in the determination of these corrections. The second method solves Planck's equation directly, obtaining an exact relation, which may be simplified by justifiable approximation to a form the same as Paschen's equation with a small correction term added.     J. H. D.

PHYSICS.—*Note on the temperature scale between 100° and 500° C.* C. W. WAIDNER and G. K. BURGESS, Bulletin Bureau of Standards, 7: 1–9. 1911.

By means of resistance thermometers reading to an accuracy of 1 in 100,000 and calibrated[1] at the ice, steam, and sulphur-boiling points, using the Callendar equation, the nitrogen constant volume temperature scale in the interval 100° to 500° C. is found to be represented to better than 0.1° C. by the following freezing and boiling points:

| Freezing | | Boiling | |
|---|---|---|---|
| Tin ... ................. | 231.9 | Naphthaline............. | 218 0 |
| Cadmium..... .. ....... | 321.0 | Benzophenone........... | 306.0 |
| Zinc . .. ... . ....... . | 419 4 | Sulphur... .......... .. | 444 7 |

G. K. B.

PHYSICS.—*On the constancy of the sulphur boiling point.* C. W. WAIDNER and G. K. BURGESS. Bulletin Bureau of Standards, 7: 127–130. 1911.

Thermocouples of platinum and other metals such as are used in high temperature measurements often give results in the sulphur boiling apparatus discordant by 1° C. or more.[2] By means of platinum-rhodium thermocouples free from inhomogeneity and notably with one of only 0.1 mm. diameter, as well as by means of a resistance thermometer of very short coil, less than 9 mm. in length and of 13.1 ohms resistance, taking only 0.006 amperes measuring current, it is shown that the point to point variation in temperature within the usual form (*loc. cit.*) of sulphur boiling apparatus is less than 0.05° C. The sulphur boiling point appears to be the most exactly defined, the most certainly reproducible, and the most constant yet studied, of all the fixed temperatures given by the chemical elements. G. K. B.

PHYSICS.—*A new form of direct-reading candle-power scale and recording device for precision photometers.* G. W. MIDDLEKAUFF. Bulletin Bureau of Standards. 7: 11–44. 1911.

In precision photometry it is necessary to take a large number of readings, which, with the subsequent calculations for candle-power, are not only fatiguing but introduce the possibility of error, especially when the observer has both to read the photometer and record the settings

[1] Bulletin Bureau of Standards, 6. 149–230. 1910.
[2] Ibid., 6. 149–230. 1910.

Furthermore, the ordinary, commercial candlepower scale cannot well be adapted to precision work because it is practically impossible to so adjust the comparison lamp as to make the scale read the exact candle-power directly, especially since at least six standards should be employed in making the adjustment.

At the Bureau of Standards these difficulties are overcome by automatically recording the photometric settings by dots on a sheet of paper, or chart, containing a special printed scale which is capable of being accurately adjusted to the record. The chart is wrapped on a cylinder which rests on the bench with its axis parallel to the photometer bar. By pressing a key located on the photometer carriage a record dot is printed at the correct position on the chart for each setting, as it is made, and as the key opens, the cylinder, by means of an electrically driven secondary clock, is advanced a short distance thus preventing any two dots from coinciding and at the same time showing the order in which the readings are made. A large number of settings on a given lamp are thus made quickly and without prejudice and their mean, which corresponds to the center of mass of the cluster of record dots, is readily and accurately determined.

The special scale is rectangular in form, the upper and lower sides being graduated into linear candle-power scales corresponding, respectively, to the extreme adjustments of the comparison lamp within which it is desired to work. The points of division in these two linear scales are joined by straight lines, thus producing within the rectangle an indefinite number of linear candle-power scales, so that for any arbitrary adjustment of the comparison lamp between the limits chosen there will be a scale which will exactly fit the record printed by dots on the chart. The proper one is easily determined by preliminary readings on the standards and the values of the unknown lamps are read off to the nearest one-hundredth of a candle.

This scale is adaptable to all arrangements of the photometer and is adaptable also to the measurement, without the use of rotating sectored disks, of lamps differing considerably from one another or from the standards in candlepower; in which case, to make the record of all settings fall on the chart, the various lamps when measured are placed, respectively, according to their intensity, at different points along the photometer bar.

In each and every case the scale reads in candle-power directly, and if the values be written on the chart when they are first read from the scale it becomes a simple matter for a second reader to check the work of the first entirely by inspection.　　　　　　　　　　　　　　　　G. W. M.

INORGANIC CHEMISTRY.—*The rôle of hydrolysis in geological chemistry.* ROGERS C. WELLS. Economic Geology, 6: 211–217. 1911.

Owing to hydrolysis most solutions that are active in geologic changes are either alkaline or acid, rarely neutral. The nature of the hydrolytic reaction for several salts is described and it is shown that geologic action may often be proportional to the concentration of hydroxyl ion in a solution even though, as with carbonates, it is a "salt" which is assumed to be present. Owing to the increasing ionization of water at high temperatures, as well as the increasing hydrolysis of salts, hydrolysis becomes extremely marked at such temperatures. This may help to explain the action of water as a "mineralizer."                R. C. W.

MINERALOGY.—*The relation of bornite and chalcocite in the copper ores of the Virgilina District of North Carolina and Virginia.* FRANCIS BAKER LANEY, Geological Survey. Proceedings of the United States National Museum, No. 1835, 40: 513–524, Pls. 63–69. 1911.

The rocks of the Virgilina District are greenstone and sericitic schists cut by granite and gabbro. The intrusive rocks show no schistosity. The schists have been derived from volcano-sedimentary rocks of two types—andesite and quartz porphyry, with tuffs corresponding to these rock types. Their age is probably early Paleozoic.

The veins have a more northerly trend than the schistosity of the country rock. Their filling is quartz with local and varying amounts of epidote and calcite. The ore-bearing veins are confined to the more basic portions of the greenstone schists, and the ore lies in well-defined shoots.

The ore minerals are bornite and chalcocite. They are chiefly in quartz, but are not confined to any one of the gangue minerals. Bornite is in slight excess over chalcocite and is apparently of only one period of deposition. Chalcocite is of two periods—one confined to the upper portions of the vein, younger than, and filling a network of minute fractures in, the bornite; the other contemporaneous and intergrown often crystallographically with it. There is no evidence that any of the bornite is secondary. It is, therefore, clear that in the Virgilina District the greater part of the chalcocite is a primary mineral contemporaneous with the bornite.                F. B. L.

MINERALOGY.—*Natramblygonite, a new mineral.* WALDEMAR T. SCHALLER. American Journal of Science, 31: 48–50. 1911.

Natramblygonite is a soda amblygonite, or a hydrofluophosphate of alumina and soda with the soda in part replaced by lithia. This mineral was found near Cañon City, Colorado, and its analysis gave the results: $P_2O_5$, 44.35; $Al_2O_3$, 33.59; $Li_2O$, 3.21; $Na_2O$, 11.23; $K_2O$, 0.14; $H_2O$, 4.78; F, 5.63; deduct O for F, 2.37; total, 100.56. W. T. S.

MINERALOGY.—*Thaumasite from Beaver County, Utah.* B. S. BUTLER and W. T. SCHALLER. American Journal of Science, 31: 131–134. 1911.

The rare mineral thaumasite was found in veins in altered limestone in the Old Hickory mine, Rocky Range, Rocky district, Beaver Co., Utah. Its properties agree with those of thaumasite from other localities and the analysis gives the formula $3CaO.SiO_2.SO_3.CO_2.15H_2O$.

B. S. B.

MINERALOGY.—*Bismuth ochers from San Diego County, California.* WALDEMAR T. SCHALLER. Journal American Chemical Society, 33: 162–166. 1911.

The bismuth ochers result from the oxidation of native bismuth and analyses of three samples show them to be either bismite $Bi(OH)_3$, pucherite $BiVO_4$ or mixtures of these two. It is concluded, from a study of the literature, that the anhydrous bismuth oxide, $Bi_2O_3$, probably does not occur in nature. W. T. S.

MINERALOGY.—*Krystallographische Notizen über Albit, Phenakit und Neptunit.* W. T. SCHALLER. Zeitschr. Kryst. Mineral., 48: 550–558. 1911.

Some rare crystal forms are described on albite from Marin Co., California. Phenakite from New Hampshire and neptunite (new form) from California are described crystallographically. All the known forms, with coördinate angles and literature references, of phenakite and neptunite are brought together in tables. W. T. S.

GEOLOGY.—*A geologic reconnaissance in southeastern Seward Peninsula and the Norton Bay-Nulato region, Alaska.* PHILIP S. SMITH and HENRY M. EAKIN. Bulletin U. S. Geological Survey No. 449. Pp. 141, with maps, sections, and views. 1911.

The region described extends from the Yukon River near the mouth of the Koyukuk westward to Council in Seward Peninsula. There are two

main geologic provinces—a Cretaceous basin to the east and an area occupied by metamorphic rocks to the west.

The Cretaceous rocks, which contain invertebrate fossils, cover a large area and have a thickness of more than 20,000 feet, with neither top nor bottom exposed. At the base of the Cretaceous section is the Ungalik conglomerate, at least a thousand feet thick, which grades upward, and probably laterally also, into the Shaktolik formation, of sandstones and shales. The sandstone is made up of fairly fresh feldspathic and ferromagnesian minerals. Cross bedding, concentric weathering, and mud-flat markings are common structures and some of the beds are lignitic.

The Ungalik and Shaktolik rocks are younger than the main igneous intrusives, but in a few places they are cut by dioritic rocks, and the mineralization effected by these has given rise to small placers. After deformation and erosion the Cretaceous rocks were covered by basaltic lavas.

In the region of metamorphic rocks are schists, limestones, and altered basic intrusives, all intricately folded and faulted. Fossils from the limestones are Silurian to Devonian-Carboniferous. The metamorphic rocks were intruded by granites and diorites after the main period of metamorphism but before the deposition of the Cretaceous sediments.

The metamorphic rocks are those most mineralized, and there are two series of auriferous quartz veins—one older and one later than the period of metamorphism. Neither carries considerable sulphides. These veins are the sources from which the placer deposits in the western part of the region, most notably near Council and Bluff, have been derived.                                                     P. S. S.

GEOLOGY.—*The State Geological Surveys of the United States.* Compiled under the direction of C. W. HAYES. Bulletin U. S. Geological Survey No. 465. Pp. 177. 1911.

Material compiled in coöperation with the administrative officers directing State geological surveys. Thirty-six States now have organizations for carrying on geological work.

PALEONTOLOGY.—*The fauna of the Moorefield shale of Arkansas.* GEORGE H. GIRTY. Bulletin U. S. Geological Survey No. 439. Pp. 148, 15 Pls. 1911.

The Moorefield shale is a member of the Mississippian section of northern Arkansas lying above the Boone formation and below the Bates-

ville sandstone. It is a series of black shales which has near Batesville a thickness of about 225 feet, but which thins rapidly in a westward direction, so that at Marshall it is less than 30 feet thick and still farther west, in the Fayetteville region, the Batesville is reported to rest directly on the Boone.

The Moorefield fauna treated in this report was obtained in the region about Batesville and at Marshall and·comprises 89 species and varieties. Its facies is conspicuously different from those of the typical Mississippian faunas.farther north and, as pointed out by H. S. Williams, by whom its general character was first made known, it contains a number of types which taken by themselves give it, in a measure, a Devonian aspect.

The Moorefield fauna is closely related to that of the lower portion of the Caney shale of Oklahoma and the two are regarded as being in correlation. At the same time the Moorefield shale has been generally referred to the "St. Louis group" and this assignment is probably correct.                                                                                                G. H. G.

PALEONTOLOGY.—*The fauna of the phosphate beds of the Park City formation in Idaho, Wyoming, and Utah.* GEORGE H. GIRTY. Bulletin U. S. Geological Survey No. 436. Pp. 8, Pls. 7. 1911.

It is important to note that although this report bears date of 1910, its actual publication did not take place until early in the following year.

The Park City formation, named from Park City in the Wasatch Mountains of northeastern Utah, has been traced northward into Idaho, from which region the collections discussed in this report were largely made. Most of them came from the vicinity of Montpelier and of Raymond Canyon.

In this region the formation consists of two limestone members separated by a bed of dark shale about 100 feet in thickness. It is in this shale that the phosphate deposits of the Utah-Idaho-Wyoming district occur. The fossils are found chiefly in a few thin limestone sheets by which the shales are divided and especially in what is locally known as the "Cap lime," a ledge of earthy limestone about 2 feet in thickness which at Montpelier comes in near the base of the black shales just above the main phosphate bed. The fauna thus far obtained consists of 45 species and is unique in character being, like so many of our western faunas, unlike the Upper Carboniferous of the Mississippi Valley and comparable with the faunas of Asia and eastern Russia. In this report it is provisionally placed in the Pennsylvanian, but more recent data indicate that it should probably be classed as Permian.   G. H. G.

FORESTRY.—*The preservative treatment of poles.* Compiled by
WILLIAM H. KEMPFER. Forest Service Bulletin No. 84. Pp. 55,
with plates and diagrams. 1911.

Present knowledge of the results of the creosote treatment of wooden
poles is based largely on treatments made by the pressure method, using
from 8 to 12 pounds, or more, of creosote to a cubic foot of timber. The
expense incident to such treatment has been the chief hindrance to
its more general adoption for poles. Investigations of the Forest Ser-
vice have therefore been concerned with treatments which could be
applied locally without the erection of elaborate and extensive plants.
Much attention has also been given to the seasoning of poles, since proper
seasoning not only prepares poles to receive the preservative, but under
certain conditions may be in itself a means of increasing their durability.

Seasoning of poles reduces their weight usually from 16 to 30 per cent,
and even more for some species. In general, poles cut during the spring
and summer lose weight most rapidly; those cut during the autumn and
winter lose less rapidly, but more regularly.

Preservative applied to the surface of a pole by a brush may add from
one to two years to the life of timber, but permanent protection should
not be expected from the application of so small a quantity of preser-
vative. If the butt be more deeply impregnated, the life of the pole
will probably be limited by the life of the top rather than by that of the
butt. A life of 20 years for butt-treated chestnut and western cedar, and
22 years for northern white cedar poles is believed to be a conservative
estimate. In the drier western climate butt-treated pine poles can
probably be depended on to give 20 years' service.

Impregnation of many pole timbers may be accomplished in open
tanks, without the use of artificial pressure, by immersion in hot and
cold preservatives, the cold following the hot. The open tank process
has the advantage that it is possible to apply the preservative to the
butts only, with a great saving in the creosote.     FINDLEY BURNS.

FORESTRY—*Chaparral: Studies in the dwarf forests, or elfin-wood,
of Southern California.* FRED G. PLUMMER. Forest Service Bulle-
tin No. 85. Pp. 50, with map, plates, and text figures. 1911.

True chaparral is a type of plant formation which occurs in several
widely separated parts of the world. In the United States it is found in
southern California over an area of about 5,500,000 acres, along the axis
of the Sierra for a distance of about 450 miles. The formation is known
to plant ecologists as sclerophyllous woodland, and has many local

names, such as scrub, elfin-wood, bush-forest, heath-scrub, maqui, shrub, steppe, etc. It may be described (though not defined) as a mixed forest of stunted trees, the result of peculiar climatic conditions, such as deficiency of moisture, excessive transpiration, barren soil, high altitude, and wind.

The economic importance of chaparral is due chiefly to the necessity of watershed protection in a region where water is scarce and is of the utmost importance for irrigation and municipal supply. In southern California chaparral protects about three-fourths of the upper watersheds of the streams along the coast. It serves to conserve and regulate the flow of streams in two ways: (1) By the root systems which penetrate the soil and assist the water to percolate, while they prevent erosion; and (2) by lessening the evaporation.

In the chaparral, as it now exists, those species best suited for cover are not the most numerous. The growth of the better sorts should be encouraged, and possibly some foreign species should be introduced.

F. G. P.

FISHERIES.—*The food value of sea mussels.* IRVING A. FIELD, U. S. Fisheries Laboratory, Woods Hole. Bulletin of the Bureau of Fisheries, 29: 85–128. Pls. 18–25, figs. 2. 1911.

Sea mussels (*Mytilus edulis*) are so palatable and nutritious, and are likewise so abundant and available, that to neglect them for table use is waste. They are found along the coasts of practically all the northern half of the Northern Hemisphere, and in the slightly brackish bays and estuaries of New Jersey, Long Island, Rhode Island, and Massachusetts they exist in beds so extensive that they can be collected daily by the ton. Many have pronounced them equal or superior in flavor to the oyster, and obviously to the coastal population they would be a cheap food. They are, moreover, in season when the oyster is out of season, they breed prolifically, and, requiring less special conditions for growth than does the oyster, they may be more easily cultivated.

The readiness with which mussels spoil is the one difficulty in marketing them raw, for they must be used within 24 hours after being taken from the water. Dr. Field finds, however, that canned or pickled they will retain the natural flavor for months. He describes preserving methods, developed by his experiments, and appends a number of recipes for preparing mussels for the table.

While the main purpose of the report is practical and directed to the encouragement of an industry new to America, a large part of Dr. Field's

text is devoted to the natural history of the mussel, and includes chapters describing experiments by Dr. C. L. Alsberg to determine the available protein in the mussel meats, and by Dr. Donald Van Slyke, assisted by Messrs. W. M. Clark and C. B. Bennett, to determine the rate of digestion and proportion of nutriment absorbed from cooked mussels and squid compared with beef as a standard.          E. M. SMITH.

FISHERIES.—*The fisheries of Alaska in 1910.*  M. C. MARSH and JOHN N. COBB.  Bureau of Fisheries, Document 746.  Pp. 72. 1911.

While the original duties of the Alaska fisheries service related entirely to the enforcement of the salmon fishery laws, the scope of its usefulness, and consequently of the agents' reports, has widened to include not only operations and statistics but observations of all conditions affecting all Alaska fisheries and, with the exception of the fur seals on the Pribilof Islands, the capture of all fur-bearing animals in Alaska as well.  An important feature of the work in relation to the salmon is a series of investigations designed to throw light on the biological phenomena of the spawning runs.

Wood and Nushagak rivers, in the Bristol Bay region, were closed to all fishing in 1908, in which year, with coöperation of the packers, plans were made for a count of the salmon which reached the spawning grounds in Wood River.  For this purpose a rack was constructed at the foot of Lake Aleknagik, at the headwaters of the river, in such manner that all arriving fish must pass through a gate sufficiently small to permit of an accurate record of their numbers.  These figures, with the known catch in Nushagak Bay, outside the mouth of Wood River, furnish a census of the run and hence significant information as to the increment of salmon from natural spawning.  Carried through several years already and to be continued for several years more, such counts are expected to afford definite scientific basis for regulation of the salmon fishery.  Observations so far indicate that the Nushagak fisheries will be maintained at their present ample productiveness if 30 per cent of the run reaches the spawning grounds.          E. M. SMITH.

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# PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES ·

## THE GEOLOGICAL SOCIETY OF WASHINGTON

At the 239th meeting, at the Cosmos Club, February 8, 1911, Prof. Frank Leverett upon invitation presented an informal communication on the investigations of glacial geology that have been carried on in Minnesota during the past year.

*Some exceptional conditions of petroleum accumulation.* C. W. Hayes. ʾNo abstract.

*The scheelite deposits at Atolia, California.* F. L. Hess. No abstract.

*Some features of graphite in the United States.* Edson S. Bastin.

This paper was devoted largely to a description of certain graphite deposits of the Adirondack Region in New York. Geological and chemical evidence was advanced to show that some of them were formed by the dynamic metamorphism of carbonaceous sediments and that others, notably the deposit at Lead Hill near Ticonderoga, were formed by dynamic metamorphism succeeded by igneous metamo.phism. Evidence was given that the graphite at Lead Hill crystallized at temperatures below 575° C. Most of the material of this paper is published in *Economic Geology,* Vol. V, pp. 134–157, 1910.

The 240th meeting, held in the Cosmos Club, February 22, 1911, was devoted to a discussion on the subject, *Geographical descriptions in geological publications.*

The program opened with an address by Prof. William Morris Davis, who contended for the adoption of a systematic method of geographical description such as would speak in terms of physiographic history. This address was followed by a discussion, in which the following members took part: M. R. Campbell, A. H. Brooks, Sydney Paige, Whitman Cross, Miss Jennie T. Martin, H. M. Eakin, David White, H. E. Gregory, G. O. Smith and W. M. Davis. ROBERT ANDERSON, *Secretary.*

At the 241st meeting, held in the Cosmos Club, March 8, 1911, Mr. L. D. Burling described a method by means of which very clear results can be obtained in photographing fossils and other opaque objects by reflected light, and photographs were exhibited. Dr. C. D. Walcott exhibited and described lantern slides of panoramic views obtained in the Glacier National Park and in adjacent portions of Canada.

*General description of the Glacier National Park, Montana.* M. R. Campbell.

*The glaciers and glacial sculpture of the Park.*   F. E. Matthes.   Both papers were illustrated.                               EDSON S. BASTIN, *Secretary.*

The 242nd meeting was held in the Cosmos Club, March 22, 1911.

*The stability ranges of minerals with special reference to the geologic thermometer scale.*   Fred E. Wright.

The physico-chemical systems represented by rocks and the geologic forces which act upon these systems are often so complex that it is not possible at present to solve completely the problems which they present and to state definitely the behaviour of any particular rock or magma under the different conditions of temperature and pressure which may. arise.   It is important, therefore, that limits of temperature and pressure be established, beyond which any given system or any component of the system is no longer stable but undergoes change.   These limits mark points on the geologic thermometer scale or pressure gauge and place definite boundaries to the region in which the observed reactions have taken place.   At these points an abrupt shift in the equilibrium of the system occurs and produces profound changes in the system.

The most important thermometric points which may be of service in this connection are: (a) Enantiotropic inversion temperatures of minerals, as that of $\alpha$ quartz into $\beta$ quartz; (b) temperature limits beyond which monotropic or isomeric forms cannot exist, as the temperature 450°, above which marcasite passes at atmospheric pressure into pyrite· (c) stability ranges of enantiotropic forms and of minerals which dissociate or decompose at higher temperatures, as the dissociation temperatures, for different pressures, of calcite and other carbonates or of certain of the garnets and many other contact minerals; (d) melting temperatures of stable minerals and of eutectics  (e) temperatures beyond which any physical property acquires a permanent set and by virtue of internal friction or other cause does not revert to its original state on cooling.   In applying these data of laboratory experiment to geologic problems, it is important to note the conditions under which the data were obtained and the effect which other conditions of pressure or solution may have exerted on the observed points of equilibrium change.

*Physiographic studies on the south slope of the San Juan Mountains, Colo.*   Wallace W. Atwood.

The glacial features on the south slope of the San Juan range do not differ from those which have been described by various writers in the high mountains of the West.   Moraines of two epochs have been recognized and outwash deposits are associated with each.   On ridges above the limit of ice action are certain gravel-strewn surfaces, which, if extended, would form a plain with gently rolling topography.   This plain, sloping away from the range, would show distinct down warping at its base, and merge with the upland surfaces of the neighboring plateaus.   These gravel-strewn upland surfaces are probably portions of a deformed peneplain.   Beyond the mountains in the plateau district the peneplain

surfaces are mantled by a heavy deposit of bowlder-gravels. The bowlders range from one to five feet in diameter and extend at least fifty miles from the base of the range. Even at that distance some of the bowlders are three feet in diameter. These deposits are interpreted as portions of alluvial fans spread out upon the plateaus about the margin of the San Juan dome, following the redoming of that area and the associated deformation of the peneplain. Subsequently to the laying down of these gravels there were at least two distinct stages in the dissection of the plateau prior to glaciation. The earlier of these has been called the Bowlder-mesa stage. During that time broad areas were reduced to the local base level of erosion and strewn with vast quantities of gravels. The later stage has been called the Oxford stage. During this period the areas of softer rocks were reduced to late maturity or early old age in erosion topography. In the Bowlder-mesa and Oxford stages the mountain canyons were deepened and widened and remnants of these ancient valleys appear to-day as benches in the mountain canyons. Succeeding these erosion intervals, associated with which there were evidently periods of mountain growth in the San Juan region, was the glacial period. During the glacial or inter-glacial epochs mountain growth probably continued and there is reason to believe that some movement occurred after the disappearance of the last glacier.

*Geological features bearing on the construction of the Panama Canal.* C. W. Hayes.

This paper reported the results of a brief visit to the Canal Zone made for the purpose of determining the cause of and possible remedy for slides occurring in the side walls of the canal, which were giving much trouble to the engineers in charge.

In general the side slope practicable in any excavation depends on (1) depth, (2) character of materials, and (3) geological structure. Examination of the cut indicates that serious difficulty through failure of slopes will be experienced only in the section between Empire and Pedro Miguel. Small slides will occur outside of this section, as at La Pita, but they are due to exceptional conditions and will be relatively unimportant.

Within the section defined above are four classes of materials: (1) *Sedimentary rocks.* This class includes (a) volcanic agglomerates ejected from volcanoes in the form of angular fragments varying in size from the finest dust to several inches in diameter; deposited in water but very imperfectly bedded; generally bluish green; moderately hard when first exposed but crumbling rapidly in contact with the air. (b) Fine blue, red or black clays, composed largely of volcanic dust which has been transported and deposited by water and is well bedded; like the agglomerate, moderately hard when first exposed, but crumbling even more rapidly in contact with the air. (c) Lignite coal or black carbonaceous clay; beds one to three feet thick interstratified with (b). These beds (a), (b) and (c) with some unimportant sandstones and limestones constitute the Culebra formation of Tertiary age. (2) *Intrusive igneous rocks:* These are chiefly large masses of dark andesitic rock which

have been forced upward into the sedimentary beds, in some cases in a fluid condition but more generally after having solidified. The intrusion was accompanied by tilting and crushing of the once horizontal sedimentary beds. The andesite is generally intersected by numerous joints, but does not disintegrate readily on exposure, and where supported below will stand in vertical slopes. Gold Hill and Contractor Hill are examples of these andesitic intrusive masses. All the other high hills in the Culebra section of the Zone are apparently due to the presence of similar rocks. (3) *Lava flows:* A flow of light gray trachytic lava, 20 to 30 feet thick, is conformably interbedded with the Culebra clays throughout the central portion of the cut. The trachyte does not disintegrate readily, but by reason of its abundant joints it affords no support to the clays above. (4) *Residual clays:* The rocks in this region are deeply weathered and the original surface is covered with residual clay, derived directly from the rocks on which it rests. It is thinnest over the intrusive andesites, which decay less rapidly than the sedimentary rocks, and is thickest over those sedimentary rocks that have been so fractured as to permit the easy percolation of water.

The original "three on two" slopes have failed to stand at numerous points. Varying conditions have given rise to three classes of failures which may be designated (1) surface flows; (2) structural breaks; (3) surface disintegration.

Wherever the residual clay rests on an inclined rock surface and the lateral support is removed, as when a trench is excavated, a portion of the mass tends to flow. The material has no cohesion and very slight adhesion to the underlying rock. It acts like a viscous fluid and may flow on slopes as low as one on seven or eight. Having started it may gather sufficient momentum to carry down portions of the underlying unweathered rock, particularly if the latter is much fractured. The Cucaracha and Paraiso slides are of this type.

Every variety of rock has a limiting strength beyond which it crushes or flows. The crushing strength varies between wide limits and is lowered when one or more sides of the block are unsupported. The weakest member in the sedimentary series in the Culebra Cut is the lignite or lignitic clay. When lateral support is removed from a lignite bed it tends to give way under the overlying weight and a slide results. This may occur if the weak bed is merely unloaded by excavating, in which case it bulges up in the excavation. This type has occurred at various points between Empire and Cold Hill and in nearly every case the immediate cause appears to be the failure of a lignite bed in consequence of excavation. These structural breaks offer more serious difficulties than the surface flows, and the obvious prevention is to make the slopes sufficiently low so that the weakest rock is not loaded beyond its crushing strength. In the section of the canal threatened by slides of this type *less material will have to be removed if the slopes are lowered before the break occurs.*

As previously stated, all the sedimentary rocks of this region disintegrate rapidly when exposed to the air. They first crumble into small angular fragments and eventually into the finest powder. Slopes cut

in such rocks rapidly disintegrate and crumble until they reach an angle on which the products of disintegration will form a protective mantle. Vegetation greatly assists in this protection.    While the  failure of the canal slopes from this cause will not be a serious matter, it will involve the removal of a large amount of material in the aggregate and necessitate constant attention for a long time.    Under certain conditions this surface disintegration becomes a more serious matter.    For example, the contact between the intrusive andesite of Contractor Hill and the sedimentary clays, dips away from the canal at an angle of 55°.    The crumbling of the clays below the contact leaves the andesite mass overhanging, and the overhang will  increase as the canal is deepened and as more clay is exposed.    With a rock so fractured as the andesite this condition is unsafe and the exposed surface of the underlying clay should be protected from further disintegration by a layer of concrete.

ROBERT ANDERSON, *Secretary*.

PHYSICS.—*Melting temperatures of sodium and lithium meta-silicates.* F. M. JAEGER. Communicated by A. L. Day.

In studying the heating and cooling curves of the metasilicates of sodium and lithium, I was led by the rapid rate of crystallization of the lithium salt to investigate whether the temperature of change of state of this salt might not prove a favorable constant temperature for the calibration of thermoelements. No good fixed point has yet been found for calibration purposes in the neighborhood of 1200° C., intermediate between the copper point (1082.6°) and the diopside point (1391°).

The material was prepared by mixing the proper quantities of pure lithium carbonate with a specially purified quartz and grinding them together for some hours. After grinding, the mixed powder was melted in a Fletcher furnace, cooled, and again ground for six hours in an agate mortar. This process was repeated three times to insure homogeneity. The analysis of the product showed 67.2 per cent $SiO_2$ and 32.7 per cent $Li_2O$, a loss of about 0.5 per cent of $Li_2O$. A corresponding quantity of the lithium salt was then added to the preparation and the mixture again ground and melted alternately, three times, as before. Subsequent analysis showed again a slight excess of silica and a third portion of lithium carbonate was accordingly added. This preparation when ground and melted three times gave a homogeneous mixture as follows, the lithium being determined as sulphate:

*Analysis of lithium silicate*

| | |
|---|---|
| $SiO_2$..... ... ................. 66.60 | $K_2O$ ... . .... ............. none |
| (Calculated 66.63 per cent) | $Na_2O$............................. 0.51 |
| $Fe_2O_3$..........................0 016 | $Li_2O$ ...... .. ................... 32.80 |
| CaO...........................0.034 | (Calculated 33.37 per cent) |
| FeO..........................none | |

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The lithium silicate compound crystallizes beautifully in white glistening needles with perfect cleavage in fine colorless lamellæ, like mica. The microscopic examination showed the preparation to be quite homogeneous except for a few tiny air bubbles between the lamellæ which were probably crowded out in the crystallization of the mass. The crystallization is accompanied by a considerable development of heat and increase of volume. The needles are biaxial with rectangular extinction and very strong birefiingence. The direction of elongation of the needles is that of the larger refractive index and the principal plane of cleavage appears nearly parallel to the plane of the optic axis. The angle of the optic axes is rather large. Microscopical examination yielded the following additional data: Refractive index in the direction of elongation of the needles, 1.609; perpendicular to the direction of elongation, 1.589, giving a birefringence of about 0.020, corresponding nearly to augite: direct measurement of the birefringence with the Babinet compensator gave 0.019, in good agreement with the calculated value.

The specific gravity of the finely powdered substance, determined by the picnometer method with xylene (0.8587) gave 2.5203 at 24.9° C.

Three different samples of this preparation were heated successively in the platinum furnace with all the precautions which have been found desirable in the determination of standard melting points in the Geophysical Laboratory. The standard thermoelement C, used by Day and Sosman in the work with the nitrogen thermometer, was used. The results obtained are given on page 51. Prior to these determinations, the thermoelement was examined for homogeneity and found to be free from contamination.

The melting temperature (11,953 microvolts = 1201.8° C.) is as sharply defined as that of diopside and quite as reproducible, as can be readily seen from the experiments themselves.

While the melting temperature of pure lithium metasilicate is sharply defined, the solidifying temperature obtained by cooling down the molten mass is completely dependent upon the rate of cooling, notwithstanding the tendency to crystallize and the

rapidity with which crystallization proceeds. Actual measurements will best illustrate this. In one trial the liquid silicate cooled to 10,914 microvolts where it crystallized suddenly with a rapid rise of temperature to 11,585 microvolts. In a second attempt, the charge cooled to 10,857 microvolts, followed by a rise of temperature to 11,650 microvolts. In a third experiment, the thermoelement was moved within the charge at a temperature corresponding to 11,075 microvolts, whereby crystallization was precipitated at once and the temperature rose to 11,720 microvolts during crystallization. It is therefore clear that the observed temperature of solidification is dependent upon the amount of undercooling and other accidental conditions which chance to surround the charge. It will be noted, furthermore, that the undercooling may amount to more than 1000 microvolts, (approximately equivalent to 100°).

*Melting temperatures of lithium silicate*

| SAMPLE NO. | RATE OF HEATING | ELECTROMOTIVE FORCE | |
|---|---|---|---|
| | *microvolts per ½ min.* | *microvolts* | |
| Sample I . ... . .. .. $\Big\{$ | 22 | 11957 | |
| | 32 | 11953 | |
| | | Mean | 11955 = 1201.9° C. |
| Sample II .. .... . . $\Big\{$ | 12 | 11946 | |
| | 24 | 11956 | |
| | 24 | 11956 | |
| | 40 | 11953 | |
| | | Mean | 11953 = 1201.8° C. |
| Sample III  .. .  . . $\Big\{$ | 11 | 11947 | |
| | 26 | 11956 | |
| ° | | Mean | 11952 = 1201.8° C. |

From these experiments, it again appears clear that solidifying temperatures may have no significance whatever as equilibrium temperatures, but vary with the conditions which chance to surround the melt and with its previous treatment.

This fact probably accounts for the variable results obtained by different observers who have studied the solidifying tempera-

ture of *sodium metasilicate* which crystallizes much more slowly than the corresponding lithium salt and often shows undercooling amounting to 150° C.   This may be seen from the following data:

*Solidifying temperature of sodium metasilicate*
1007° (Kultascheff)    1018° (Wallace)    1055° (Guertler)    1056° (Van Klooster)

A determination of the melting point of an analyzed specimen of a rather pure sodium metasilicate ($SiO_2$ 49.3 per cent, $Na_2O$ 50.6 per cent) made under the same conditions which obtained in the preceding experiments, gave the following values with three different rates of heating:  1086°, 1088° and 1088°.  The true temperature of change of state is therefore very nearly 1088° C. (10,600 microvolts in terms of element G, Day and Sosman).

Cooling this particular charge for an observation of the solidifying temperature gave, upon the first trial, 1046°, following undercooling to 1017°; upon the second trial, 1050°.   In the third trial, a particle of solid substance was introduced which precipitated crystallization suddenly at 1057°.   The solidifying temperature was therefore much below the melting temperature, even under the most favorable conditions of work.   It appears to follow from this that the solidifying temperatures of sodium metasilicate given in the literature have little or no significance as determinations of real equilibria.   The true melting point is 1088° C.

The refractive indices of the sodium salt are about 1.527 and 1.518 and the birefringence about 0.01.

PHYSICS.—*A method for determining the density of certain solids by means of Rohrbach's solution having a standard refractive index.*   H. E. MERWIN, Geophysical Laboratory.   Communicated by A. L. Day.   To appear in the American Journal of Science.

By means of Rohrbach's solution so prepared that the relation of its density to its refractive index is known, the density of suitable solids between 2 and 3.5 can be determined rapidly and accurately on the total refractometer by finding the refractive index of the solution while fragments of the solid are suspended in it.

The solution saturated with mercuric iodide at 20° and at the density of ordinary orthorhombic sulphur (2.07) has, for concentrations between 2.25 and 3.4, the relation $d = 5.39\,n - 6.0865$, where $d$ is the density and $n$ the refractive index.

ELECTRICITY.—*A study of the current transformer with particular reference to iron loss.* P. G. AGNEW. Communicated by E. B. Rosa. To appear in the Bulletin of the Bureau of Standards.

It has been generally assumed that the ratio of a current transformer always decreases with increasing current, but examples can be given in which the ratio curve slopes in the opposite direction, or even passes through a maximum. The ratio and phase angle performance may be accurately computed from the magnetic data of the core. In nearly all cases the slope of the ratio curve may be qualitatively predicted from the value of the Steinmetz exponent in the equation $W = kB$ where $W$ = total iron loss, $B$ = max. flux, $k$ and $c$ are constants. But the iron losses, particularly at the low flux densities used, depart too widely from such a simple law for accurate work.

The slope of the ratio curve may be accurately computed from the slope of the curve obtained by plotting the core loss against the flux on logarithmic paper. It is proposed that this logarithmic slope, or logarithmic derivative shall be called the "ratio of variation." It is much more useful than an actual exponent. The methods now in use for determining the "exponent" fail to give a true exponent that will satisfy an equation of the form $W = kB$ unless $z$ is a constant. The quantity actually determined by these methods is the ratio of variation.

The wave form of the secondary current of a transformer may be considered to be the same as that of the primary current for even the most precise measurements, as the distortion within the transformer is entirely negligible, as may be shown experimentally. For a good transformer with sinusoidal primary this distortion amounts to less than a part in a million in terms of effective values. While the effect of ordinary variations in wave form on ratio and phase angle may be detected by accurate measurements,

it is too small to be of practical importance, being of the same order of magnitude as the effect of small changes in frequency.

The null methods now in use for the accurate determination of ratio and phase angle all give theoretically currect results, well within the experimental error, so that the accuracy attainable is decidedly greater than is actually required in practice.

GEOCHEMISTRY.—*Minerals and rocks of the composition* $MgSiO_3$–$CaSiO_3$–$FeSiO_3$. ROBERT B. SOSMAN, Geophysical Laboratory. Communicated by A. L. Day.

This paper is a partial report on a study, from the statistical standpoint, of certain rocks and minerals having a composition corresponding to a mixture of the metasilicates of magnesia, lime, and ferrous iron. The method of treatment is already familiar to mineralogists and petrologists through the publications of Vogt.

Although the studies of Vogt have indicated relationships of great importance in the understanding of rocks, they are open to the criticism that the systems treated are too complicated to yield anything more than indications. It should be remembered that the existence of a 2-component or a 3-component system depends upon the properties of the chemical substances entering into it, and upon the range of temperatures and pressures under consideration, and not simply upon the fact that it is made up of two or of three distinct minerals. To treat a mixture of diopside and olivine, for example, as a 2-component system may serve to conceal as many relationships as it brings out. This mixture can be completely discussed only as a part of the 3-component system $SiO_2$–$MgO$–$CaO$.

There are on record analyses of a few rocks and of a large number of minerals that are practically completely made up of the three metasilicates, $MgSiO_3$, $CaSiO_3$, and $FeSiO_3$, with almost no alumina, ferric iron, or other oxides. These analyses, in combination with the experimental data of this laboratory on the system $MgSiO_3$–$CaSiO_3$ form the material for the accompanying 3-component diagram, fig. 1. The evidence is not complete that these three *can* be treated as a 3-component system. But the

existing data indicate that these metasilicates do not react with one another to form any compound that can not be represented in terms of the components, nor do they appear to dissociate to any appreciable extent into their constituent oxides. We may
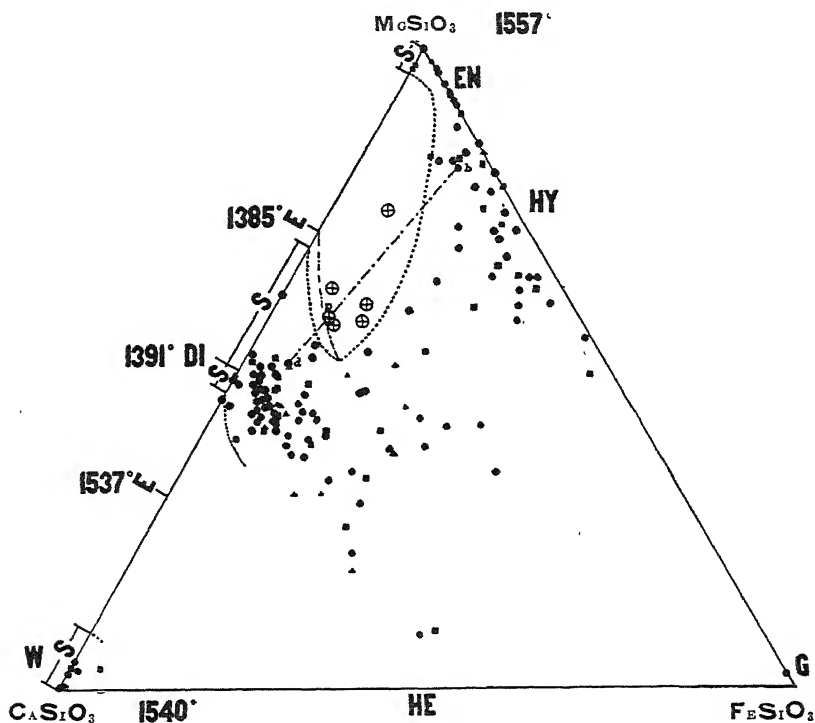


Fig. 1. Diagram of analyses of minerals and rocks in the 3-component system $MgSiO_3$-$CaSiO_3$-$FeSiO_3$. Black dots are mineral analyses; circles are rock analyses. *EN*, enstatite; *HY*, hypersthene; *G*, grünerite (amphibole); *HE*, hedenbergite; *W*, wollastonite; *DI*, diopside; *E*, eutectic; *S*, solid solution.

assume for the present, then, that up to at least 1600° and at ordinary pressures they form a true 3-component system.

The material for the diagram consists of analyses of pyroxenite rocks and pyroxene minerals from the tables of Dana, Clarke, Washington, Wahl, and a number of scattered sources. The data are not claimed to be complete.

The analyses have first been calculated to molecular percent-

ages of the constituent oxides, $SiO_2$, $MgO$, $CaO$, $FeO$, $Al_2O_3$, etc. Only those analyses were used in which the sum of $SiO_2$, $MgO$, $CaO$, and $FeO$ exceeded 94 molecular per cent, and in the majority of cases this sum exceeds 97 per cent. The analyses were then recalculated to a basis of 100 per cent metasilicates, and plotted in the diagram. The black dots represent minerals having a normal metasilicate composition. Those having a slight excess of $SiO_2$ (2 to 4 molecular per cent) are represented by triangles, and those with a slight deficiency of $SiO_2$, by squares. The open circles with crosses represent rock analyses. The rocks in question all consist of two minerals.

The following facts are brought out by the diagram:

1. The rock analyses and the mineral analyses fall into two separate parts of the diagram and can be separated by a line. This line probably represents the boundary between magma compositions that will form homogeneous solid solutions, and magmas that will separate into two different solid solutions between which there is a eutectic. The rock analyses lie in the "eutectic field," the minerals outside of it.

To be consistent, such a diagram should represent conditions of equilibrium throughout. This diagram is inconsistent in that the mineral enstatite appears in the $MgSiO_3$ corner. Enstatite has been shown to be an unstable form, next in order of stability after clino-enstatite or $\beta$-$MgSiO_3$, which has rarely been found in nature. It is to be expected, however, that the relations of solid solution and eutectic proportion will not be greatly different for this false equilibrium, which may indeed have been a true equilibrium under the conditions of formation of these rocks. The same may be true of the neighboring orthorhombic pyroxenes, bronzite and hypersthene.

2. The two types of minerals of which these rocks are made up are in each case the two solid solutions which appear on opposite sides of the "eutectic field." On the upper or $MgSiO_3$ side they are given the names enstatite, bronzite, and hypersthene; on the $CaSiO_3$ side, diopside and diallage.

In the case of one of these rocks, described and analyzed by Williams, the composition of the constituent minerals is given.

This is the analysis marked $p$. Its two constituents, marked $b$ (bronzite )and $d$ (diopside) should lie at opposite ends of a straight line passing through $p$. The line passing through these three points is almost exactly straight, the small deviation being simply the error of analysis.

Under conditions of complete equilibrium, the analyses of minerals from igneous rocks of these compositions should all lie along the border line of the "eutectic field." If equilibrium were incomplete during solidification, the composition of the constituent minerals might lie some distance away from this boundary, as some of those plotted actually do. The diagram also includes many secondary minerals, which may have almost any composition within the solid solution portion of the diagram.

3. The mineral and rock relations just discussed agree excellently with the experimental data of this laboratory on the system $MgSiO_3$–$CaSiO_3$. Beginning with $MgSiO_3$, Allen and White find a solid solution of diopside in clino-enstatite extending to about 2 or 3 molecular per cent $CaSiO_3$. Mixtures with somewhat more $CaSiO_3$ than this separate into two solid solutions, one of the composition just given, and one having 30.5 molecular per cent $CaSiO_3$. The eutectic proportion of these two falls at the point E (29 molecular per cent $CaSiO_3$).

Corresponding to this 2-phase region we find the 2-phase pyroxenites and websterites. According to Williams, the bronzite has crystallized first in the websterites which he investigated. This fact would place the eutectic line close to the diopside side of the field, agreeing excellently with the determination of its position in the system $MgSiO_3$–$CaSiO_3$, as determined by Allen and White.

Next comes the compound diopside, $MgSiO_3.CaSiO_3$, near which we find grouped a large number of natural diopsides containing varying amounts of $FeSiO_3$, very few of them corresponding exactly to the formula because of the range of solid solution possible. On the $CaSiO_3$ side of diopside the solid solution is found to end at about 52 or 53 molecular per cent $CaSiO_3$. The mineral analyses end here also.

No 2-phase rocks corresponding to the 2-phase region between the two solid solutions of wollastonite in diopside, and diopside in

wollastonite, are known to me. The eutectic composition is at 69 molecular per cent CaSiO$_3$. At the CaSiO$_3$ end occur a number of wollastonites, all lying within the experimentally determined limits of the solid solution (9 molecular per cent MgSiO$_3$).

The diagram illustrates very well how it may become possible to classify minerals and rocks on a physico-chemical basis, starting with chemical complexity as the fundamental character. Such a classification means more to the chemist than to the mineralogist and petrologist, but it is to be hoped that it will throw increased light on the relations of the silicates from both points of view.

MINERALOGY.—*Crystallized turquoise from Virginia.* WALDE-
    MAR T. SCHALLER, Geological Survey. To appear in the
    American Journal of Science.

A sample of a well crystallized, bright blue mineral from Campbell County, Virginia, sent in for identification by Mr. J. H. Watkins, proved to be turquoise, a species hitherto known only in a cryptocrystalline condition. The mineral forms a secondary botryoidal crust on quartz. The minute crystals composing this crust have a rhombic shape and, like the crystals of chalcosiderite, with which turquoise is isomorphous, are triclinic. As the angles of the two species are very close, the crystallographic elements of chalcosiderite are taken for turquoise: $a : b : c = 0.7910 : 1 : 0.6051$. $\alpha = 92°58'$, $\beta = 93°30'$, $\gamma = 107°41'$. Crystal forms of turquoise: $a \{100\}$; $M \{1\bar{1}0\}$; $k \{0\bar{1}1\}$, large; $m \{110\}$, small; $b \{010\}$, line face. The mean refractive index is about 1.63. The double refraction is high (0.04) and the pleochroism strong, pale blue to colorless.

*Analysis and ratios of turquoise*

| | | |
|---|---|---|
| P$_2$O$_5$ | 29.84 | 2.07 |
| Al$_2$O$_3$ | 31.91 | 3.09 |
| Fe$_2$O$_3$ | 0 18 | |
| CuO | 7.87 | 0.97 |
| H$_2$O | 17.59 | 9.64 |
| Insoluble | 12.57 | |
| | 99.96 | Density = 2.84 |

The analysis of the blue crystals leads to the formula $CuO.3Al_2O_3.2P_2O_5.9H_2O$, which, as none of the water is given off below 200°, can be interpreted as $CuOH.6[Al(OH)_2].H_5.(PO_4)_4$.

A comparison with published analyses shows a very close agreement with the composition calculated from this formula. The formula of chalcosiderite should be written analogously with that of turquoise, as $CuO.3Fe_2O_3.2P_2O_5.9H_2O$ instead of with $8H_2O$.

MINERALOGY.—*Quartz and fluorite as standards of density and refractive index.* H. E. MERWIN, Geophysical Laboratory. Communicated by A. L. Day. To appear in the American Journal of Science.

The two minerals, quartz and fluorite, in clear colorless varieties, appear to be the only minerals of wide distribution that have density constant to $\pm 0.001$ and refractive index constant to $\pm 0.0001$, regardless of locality. These minerals may therefore be used as standards. The density of quartz at 20° is 2.6495 and its refractive index $\omega$ at 20° for sodium light is 1.54425. The corresponding values for fluorite are 3.180 and 1.43385.

MINERALOGY.—*The temperature stability ranges, density, chemical composition and optical and crystallographic properties of the alkali feldspars.* H. E. MERWIN, Geophysical Laboratory. Communicated by A. L. Day. To appear in the American Journal of Science.

Changes in the double refraction of sections of the alkali feldspars, observed during and after heating in the thermal microscope, indicate that both albite and orthoclase appear in two forms, the transition temperature of the low temperature $\beta$-form into the high temperature $\alpha$-form being in both cases about 900°. Sanidine has the optical properties of $\alpha$-orthoclase and adularia those of $\beta$-orthoclase. Microcline appears to be stable to its melting point. Anorthoclase behaves like microcline when heated, except that a slight change in double refraction near 900° has been observed in specimens intergrown with albite. The inversion in both orthoclase and albite is very sluggish even at 1100°. The

optic axial angles of sanidines rich in albite are larger than those of pure orthoclase. The presence of albite in orthoclase raises the density, but apparently not so much as might be expected if no volume change accompanied the mixing; the refractive index, on the other hand, is generally higher than might be expected under these conditions. As the percentage of albite increases the length of the crystallographic axis $a$ decreases. The angles in the prism zone and in the zone of the basal and front pinacoids are most affected by this change. Crystals in the same hand specimen often exhibit considerable variation in the value of these particular angles, while other angles remain practically constant. Such variations indicate that the different interfacial angles are not equally sensitive to changes in the concentration of albite in the orthoclase. The crystallographic axis $c$ appears to be slightly shorter in adularia than in sanidine.

PETROLOGY.—*A micrometer ocular with coördinate scale.* FRED. EUGENE WRIGHT. Geophysical Laboratory.

This new eyepiece[1] (Fig. 1) consists essentially of a hollow brass cylinder which fits into the microscope tube as an ordinary eyepiece and serves as support for a positive Ramsden ocular in the focal plane of which a finely divided 0.1 mm. coördinate scale is placed. The eyepiece has been designed to serve three purposes (1) that of an ordinary micrometer eyepiece, (2) that of a coördinate ocular for the geometrical analysis of rock thin sections either by the Rosiwal method or by the less accurate method of percentage areas, and (3) for the measurement of the optic axial angle of mineral plates in the thin section provided that at least one optic axis appears in the field of view. In using this eyepiece for optic axial angle measurements it is necessary first to ascertain the equivalent angular value of its different coördinates for the particular lens system of the microscope with which it is to be used; after this has been done, the observer has control over the whole visible field and can measure the optic axial angle of sections which

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[1] Made for the writer by R. Fuess Company, Steglitz, Berlin, Germany (cost 35 Marks); also by the Bausch and Lomb Optical Company, Rochester, N. Y. The ruled coördinate scale was furnished in both cases by Swift and Son, London.

show in convergent polarized light either both optic axes or only one in the field of view.[2]

The primary purpose in constructing this coördinate micrometer eyepiece has been to produce an accurate, simple measuring device which covers the entire field of view and with which the
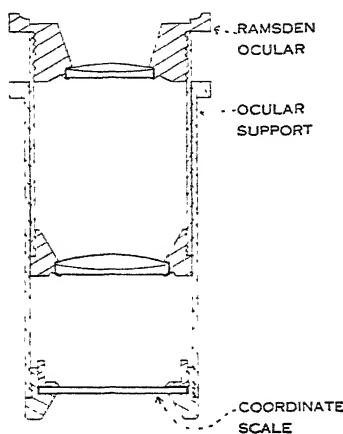


Fig. 1.   Section of micrometer ocular

optic axial angles of minerals in the thin section can be measured satisfactorily and geometric analyses of rock thin sections accomplished by either one of the two available standard methods. This eyepiece may well replace the single line micrometer eyepiece which is ordinarily furnished with petrographic microscopes.

PETROLOGY.—*The lavas of Hawaii and their relations.* WHITMAN CROSS Geological Survey.

*Introduction.*—The writer has undertaken a study of the lavas of the Hawaiian Islands with the dual object of contributing to the petrography of this interesting province and of establishing a basis for testing certain current broad generalizations concerning the genetic relations of igneous rocks. The generalizations in question are: (1) that the so-called *alkali* and *subalkali* groups of

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[2] Compare F. E. Wright, Amer. Jour. of Sci. (4), 24: 341. 1907; 29: 423. 1910; 31: 204.  1911.

rocks have a pronounced regional distribution on the earth, which may be appropriately expressed by the names Atlantic and Pacific branches or kindred, and (2) that the chemical differences of these groups are genetically connected with the tectonic distinction made by Suess between regions of subsidence due to radial contraction and zones of folding due to tangential stress. The study is not yet complete but the principal results may be forecast.

In this review of Hawaiian lavas the literature has been carefully studied; an extensive collection of rocks from Oahu and Hawaii, made by Prof. C. H. Hitchcock for the U. S. National Museum and not previously described, has been examined,[1] and also a collection from the islands of Kauai, Maui, and Hawaii, made by the writer. The chemical discussion is based on 36 apparently reliable analyses, 11 of which have been made by chemists of the U. S. Geological Survey, of rocks of the writer's collection.

*Character of Hawaiian lavas.*—The lavas of the Hawaiian volcanoes are generally basaltic in habit and have received far less attention than they deserve. As indicated by the work of Cohen, E. S. Dana, Lyons, and Silvestri the rocks range chiefly between normal basalts rich in olivine, augite, and highly calcic plagioclase, to pyroxene andesites, either free from or poor in olivine, and containing andesine or more richly sodic plagioclase. There are, however, still more basic rocks than normal basalt, such as tephrite, limburgite, nephelite, and melilite basalt, while one is practically an effusive peridotite similar to wehrlite in composition. At the other extreme there are magmas of essexitic or trachydoleritic character and some andesites nearly free from pyroxene. A soda trachyte described by the writer in 1905 is the most siliceous and feldspathic rock.

The existing analyses evidently do not cover the entire range of rock types but classifying the analyzed rocks in the quantitative system they are found scattered through 3 classes and belonging to 14 subrangs, namely: Nordmarkose–Umptekose (I–II.5.1.4.), akerose (II.5.2.4), andose (II.5.3.4), beerbachose (II.5.3.5),

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[1] The writer's thanks are due to Dr. G. P. Merrill for this opportunity.

essexose (II.6.2.4), salemose (II.6.3.4), kilanose (III.5.2.4), camptonose (III.5.3.4), ornose (III.5.3.5), auvergnose (III.5.4.4–5), uvaldose (IV.2₃.1₂.2), unnamed subrangs IV.3₄.1₃.2, and IV.3.1₂.1, wehrlose (IV.1₃.1₂.2).

As to the distribution of the chemical types on different islands it appears that the various volcanic centers are much alike in their products. The collections are too meager and analyses are too few to prove a definite peculiarity for any center. Nephelite-melilite basalts are known on three islands, Kauai, Oahu, and Maui. Strongly feldspathic andesites occur on Oahu, Maui, and Hawaii. Trachyte is known only on Hawaii. Kilauea, the most juvenile volcano of the islands, has produced lavas belonging to 6 different subrangs among the 17 rocks and analysed.

*Relations of Hawaiian lavas to the Atlantic and Pacific Kindred.*— Through the norms of the 36 analysed rocks of the islands a search has been made for the rocks of the world most nearly identical in chemical composition with each of the Hawaiian types. Washington's tables have been most useful, but many newer analyses have also been compared. For most of the Hawaiian magmas strikingly similar counterparts have been found, tho in some cases the correlated forms are not lavas.

Looking first strictly at the geographic distribution of the similar rocks it is a striking fact that they occur almost all over the world and no one province shows marked resemblance as a whole to the Hawaiian group. It seems noteworthy that comparatively few of the magmas of Hawaiian volcanoes find their nearest relatives in other islands of the Pacific. Few rocks of Tahiti, Samoa, New Zealand, and Australia are closely comparable in composition with types of the Hawaiian group.

With respect to the assignment of the Hawaiian magmas to the Atlantic or Pacific kindred, on composition alone, it certainly appears that the strongest resemblance is to the Atlantic group, yet many of the types have their analogues in the Pacific group. The trachyte of Puu Waawaa on Hawaii is nearest to alkali rocks of Cape Ann, Massachusetts, or of Norway; an andesitic type of the Kohala Mountains, in Hawaii is very nearly identical with an "augite andesite" of Pantellaria and an "åkerite" of Norway; two lavas of Kilauea may best be compared to basalts

of Hesse, or to dolerites, or to "diorites" of New Zealand and Australia; the essexitic andesites of Haleakala find their nearest relatives in "mugearite" (Harker) from the island of Skye, in "trachydolerite" from Cripple Creek, Colorado, in "carmeloite" (Lawson) of California, and among the rhombic prophyries of Norway.

One of the lavas of Kilauea is very close to a "diabase" from Cape Colony, Africa; another is most like a "kersantite" of Thuringia; a third is nearest to a basalt of Cerro San Miguel, Mexico; a fourth may best be compared to a basalt of Pantellaria or one from Cockburn Island. Space is lacking to present further details in this place, but what has been said illustrates the widespread distribution of the magmatic types which are nearest to the lavas of Hawaii in chemical composition.

With respect to conditions of occurrence it is plain that the closest analogues of the Hawaiian rocks occur partly in areas of folded mountain chains, partly in regions of faulting with subsidence, partly in districts where either such characterization of occurrence is little justified. Whatever be intended by the terms Atlantic and Pacific branches or "Sippen" the Hawaiian rocks do not fall clearly into line with either. Among them are some typical "alkali" or "Atlantic" types, some unquestionable "subalkali" or "Pacific" varieties, and a number of intermediate forms.

The Hawaiian magmas tend to show that the generalizations as to geographic distribution or the genetic relations of the "alkali" and "subalkali" groups included in current definitions of the "Atlantic and Pacific branches" or "Sippen" are far from correct. Hence in their present forms they can have no place in a petrographic system.

PALEONTOLOGY.—*Remarks on the fossil turtles accredited to the Judith River formation.* F. H. KNOWLTON, Geological Survey.

The similarity, or often apparent identity, between the turtle faunas of the Judith River and Lance formations has been employed of late, and by several paleontologists, to prove the Cre-

taceous age of the Lance formation ("Ceratops beds"). In the present paper the several species of turtles accredited to the Judith River formation are passed in critical review so far as regards the type locality and formation for each and its subsequent published distribution, both areal and vertical. The following conclusions are reached: (1) The Judith River fauna has had accredited to it at least sixteen species of fossil turtles. (2) Of these sixteen species seven are to be excluded on the sufficient ground that they do not occur in beds of Judith River age. (3) Of the nine remaining species that may have a more or less valid claim to membership in the Judith River fauna, five have their type localities in beds of Judith River and Belly River age and four in horizons above that of the Judith River. (4) Of the five typically Judith River species, four are absolutely confined to these beds, while the remaining one which has an alleged higher range is shown to be probably a composite species, possibly including three species which correspond respectively to the three horizons involved. (5) Of the four species, the types of which came from post-Judith River beds, and which are claimed to range downward into the Judith River, not a single one has a clear title to be so regarded. (6) It is plain, then, that the comparisons that have been made between "Judith River" turtles and those of higher horizons (Lance formation, "Laramie," "Ceratops beds," "Hell Creek beds," "somber beds," etc.), have not been made with species that really belong to the Judith River fauna, but with forms that actually belong to these higher beds. It is not to be wondered at that such a comparison has resulted in showing "identity" and "striking similarity."

ZOÖLOGY.—*Remarks on the nervous system and symmetry of the crinoids.* AUSTIN H. CLARK, U. S. National Museum. Communicated by Barton W. Evermann.

A year ago I published (*American Naturalist*, vol. 44, p. 243) a short note in which I showed how the nervous system of the crinoid might have originated from a nervous system of the annelid-arthropod type concurrently with a loss of directive motion. It remains to be indicated, however, in what way the

complex "dorsal" nervous system of the crinoid may be compared with the relatively simple ventral nervous system of the annelid or arthropod.

The five primary nerve cords arising from the central nerve mass are interradial in position; typically (*cf. Proceedings U. S. National Museum*, vol. 35, p. 87, fig. 1) they very soon divide into two, these two derivatives diverging and uniting with similar derivatives from the adjacent primary nerve cords just within the outer face of the radials; an intraradial commissure connects all the points of union of the branches from the primary nerve cords; five intrabasal commissures connect the two branches of each of the pairs of secondary nerve cords shortly after the division of the primary cords. From the radials single nerve cords (which may, however, exhibit slight traces of a longitudinal division), each composed of half of the two primary interradial cords in the two adjacent interradii, extend outward into the arms.

Now in monocyclic crinoids all the derivatives from the central nervous capsule, or from its extension into the stem, are interradial; and it seems to me that we must regard an interradial position as primitive for the nerve trunks arising from this central capsule. If this view is correct, the dorsal nervous system of the crinoid consists of five primary branches which divide and diverge widely so that they become united by their outer sides to the similar derivatives from adjacent primary branches, each of the five pairs of secondary nerve cords being united by two commissures, one within the basals, the other within the radials. Each one of these five pairs of secondary nerve cords with the connecting commissure is strongly suggestive of the ladder-like ventral nervous system of primitive molluscs, phyllopod crustaceans, nemerteans, peripatus, etc.

This interpretation of the complex nervous system of *Isocrinus* or *Metacrinus* as primarily composed of five interradial nerve pairs which have become united exteriorly is strongly suggested by the nervous system of the fossil genus *Encrinus* as worked out by Beyrich; *Encrinus* has biserial arms, which are more primitive than the monoserial type as seen in *Isocrinus* or *Metacrinus*,

and the derivatives from the primary interradial nerve cords do not join radially, though they approach each other. The intra-radial commissures do not extend across the radial gap between the nerve branches, but remain as five separate intraradial com-missures joining the secondary nerve cords, just like the intra-basal commissures in the pentacrinites.

The dorsal nervous system of the crinoids is therefore in effect composed of five interradial nerves and their derivatives, each of these nerves being comparable to the single double ventral nerve cord of the arthropod or of the annelid.

Whenever the arm of a crinoid branches, forming an axillary, a curious chiasma occurs within that axillary. The entering nerve at once divides, the two derivatives emerging by the two central canals of the two distal articular faces. Just before they emerge these two branches are connected by a transverse commissure. Oblique commissures run from a point just beyond the division of the main cord to the transverse commissure, crossing each other distally.

This chiasma appears to be a repetition of the nerve branching within the calyx; the two oblique commissures represent the inner branches of the two primitive nerve cords, now fused into one, which have become atrophied through disuse; the transverse com-missure represents the intrabasal commissure of the calyx, and is not developed unless the intrabasal commissure is present, being quite independent of the presence or absence of the intra-radial commissure.

The supposition that the chiasma within the axillaries is in reality a reduplication of the conditions found within the calyx rather than an original structure peculiar to and developed within the axillaries is strongly supported by the general agreement to be found between the radials and the axillaries. In interpolated division (cf. Proceedings U. S. National Museum, vol. 35, p. 113) of the post-radial series or arms, such as is seen for instance in most of the recent comatulids and in the pentacrinite genus Endoxocrinus, each axillary supports a pair of ossicles which are the exact equivalent of the first two ossicles beyond each of the other axillaries, and of the first two ossicles beyond the radials.

In its position in reference to the brachials beyond it, therefore, every axillary is essentially a dissociated radial; furthermore, in their proportionate size and shape the axillaries are correlated with the radials and not with any of the ossicles of the post-radial series; this is well brought out in such forms as *Arachnocrinus bulbosus*. There is thus very good reason for believing, aside from the direct evidence available, that the chiasma within the axillaries is in reality a dissociated reduplication of the conditions found within each of the five interradial divisions of the calyx.

The so-called ambulacral nervous system of the crinoids is entirely different from the dorsal nervous system; it is composed of extensions of or branches from the circumoral nerve ring which run out under the ambulacral grooves; these ambulacral grooves are simply radial extensions from the peristomal ring which have carried out with them the nervous structures subjacent to that ring. The circumoral nerve ring and the ambulacral nerves taken together are the equivalent of the supracœsophageal ganglion in the annelid or in the arthropod.

The chief interest in the interpretation of the crinoidal nervous system as composed of five primary interradial nerves and their derivatives lies in the relation which it suggests between the radial and the interradial structures.

From a study of the articulations in the crinoid arm (*cf. American Journal of Science*, vol. 29, p. 40; *American Naturalist*, vol. 43, p. 577) I was forced to the conclusion that the monoserial arm represents the most specialized type, being derived from the biserial by the slipping inward of the two rows of ossicles so that they come to form but a single row, and further that originally the crinoid arms were represented by ten short outgrowths which became laterally united radially; these outgrowths I ventured to suggest as the potential representatives of the ten auricles of the urchins, but developed outside of instead of within the body.

The primary interradial position of the paired nerves greatly strengthens this view; for the derivatives from the primary nerve cords have become greatly divergent, and unite among themselves to form radial nerve cords; as they are most intimately connected with the dorsal part of the ambulacral system it seems that we

must look upon the ambulacral system as primarily double, composed of two similar interradial outgrowths which have moved outward from their primitive interradial position and become united to each other by their *outer* borders.   Thus the ambulacra arose as paired interradial structures, the two components of each pair gradually moving away from each other and fusing with those of the adjacent pairs.   In the gap thus left various interradial or interambulacral plates have been developed.

It therefore follows that the five fundamental divisions of the echinoderm, the five units of the pentamerous symmetry, are not the five ambulacral series bordered with one-half of the interambulacral series on either side, but *the five interambulacral or interradial areas, plus one-half of each of the adjacent ambulacra.* In this way the fundamentally double structure of the ambulacra is easily explained.

The ventral ambulacral structures must be considered in the same light as the ventral ambulacral nerves; they are merely extensions of the ring systems about the mouth which have grown outward over the supports formed by the double dorsal ambulacral system.

Thus while the double ambulacral skeleton and dorsal nervous system of the crinoids are primarily *interradial* structures, the single processes from the various circumoral systems are primarily *radial*, arising from an enormous development of five radial buds or outgrowths on each of the circumoral structures.   The pentamerous symmetry of the crinoids, therefore, is primarily interradial in regard to the dorsal structures, but radial in regard to the ventral.

It might be argued that, as the radial plate (or corresponding structure) is always single, the dorsal ambulacral structure must be primarily single also.   The echinoderm skeleton was originally merely a spicular covering developed in the mesoderm of the body wall, comparable to that seen in certain holothurians (tho usually in this group the individual spicules have become curiously specialized) and in general comparable to the skeletons of sponges, red coral, tubipora, etc.; mechanical considerations caused the spicules to become localized in definite areas so that they have

become phylogenetically fixed as definite plates.   Any change in the mechanics of an animal with a spicular skeleton we should suppose would be immediately accompanied by either (1) a dissolution of an existing plate or plates, or (2) the sudden union of two or more plates.

In the urchins the presence of the anal opening in the anal area normally occupied  by the apical ("sur-anal") plate has resulted in preventing that plate from assembling and has kept it in most cases as a mass of small disconnected plates (*cf. Vidensk. Meddel. fra den naturahist. Forening i Kobenhavn*, 1911, p. 27) which collectively represent the primitive apical plate, the potential homologue of the crinoid stem.   Were the anal opening somewhere else we should undoubtedly find a single plate covering what is now the anal area in the urchins just as it does in the crinoids.

The sudden union of several plates is seen in such crinoids as possess three instead of five basals; the three basals collectively are the equivalent of the five collectively; but five have been reduced to three not by a fusion after formation, but by a fusion before formation, really a redivision of the basal-forming area, if it may be thus expressed, resulting from changed mechanical conditions at the time of skeleton formation.   In the same way it seems to me that the radials, originally double, have become single through the operation of mechanical factors upon a primitively diffuse spicular skeleton which in most cases has not affected the succeeding plates.

CHEMICAL STATISTICS.—*The consumption of the commoner acids in the United States.*   CHARLES E. MUNROE.

On November 10, 1904, I had the honor of calling the attention of the members of the Washington Chemical Society to the fact that as the statistics for chemical manufactures are now being collected and presented by the Bureau of the Census they could be used in solving many problems of interest and value, among them that of ascertaining the principal industries in which a given material has been used and the extent of its use.   The results of such a research should prove to be not only of general scientific and economic interest, but also of special value in legislation and

litigation where the rule of "principal use" obtains; in determining tariffs and levying taxes; in fixing freight rates; in manufacturing and other operations where the question of substitution may arise; and in other special instances. In the investigation work of the census itself such data furnishes additional checks on the returns.

I first dealt with sulphuric acid the results being published in *Bulletin 92*, p. 23, "Chemicals and allied products," for 1905;

TABLE I

CONSUMPTION OF MURIATIC OR HYDROCHLORIC ACID

| PRODUCTION | 1900 Pounds 134,229,012 | 1905 Pounds 188,538,396 |
|---|---|---|
| *Consumption* | 1900 *Pounds* | 1905 *Pounds* |
| Bleaching materials　.. | 908,000 | 1,004,000 |
| Chrome tannage.. | 5,000,000 | 6,000,000 |
| Cleaning façades. | 3,000,000 | 4,000,000 |
| Disinfectants. . | 2,500,000 | 3,200,000 |
| Dyestuffs . .... | 6,559,464 | 7,632,027 |
| Fine chemicals.... | 1,146,697 | 1,181,078 |
| General chemicals | 3,488,000 | 13,096,827 |
| Glucose making.... | 10,846,828 | 12,283,466 |
| Glue making .... | 38,186,338 | 61,795,150 |
| Olive curing.... | 2,500,000 | 3,500,000 |
| Paper making .. | 3,000,000 | 4,000,000 |
| Pickling metals........ .. | 27,000,000 | 30,000,000 |
| Reducing and refining of metals | 15,357,680 | 24,729,290 |
| Soap making... ... | 400,000 | 393,246 |
| Soldering............ | 4,000,000 | 3,000,000 |
| Textile manufacture.. | 6,000,000 | 7,000,000 |
| Washing bone black.... | 1,500,000 | 1,750,000 |
| Washing sand and clay. | 1,500,000 | 2,000,000 |
| All other uses........... | 1,336,005 | 1,973,312 |

then salt, published in *Bulletin 83*, p. 82 "Salt" for 1905; and then nitrate of soda published in the *Journal of Industrial and Engineering Chemistry*, Vol. I, May, 1909.  An application of the results is shown in "The nitrogen question from the military standpoint" published on pages 225–236 of the *Smithsonian Report* for 1909.

I have been now engaged for several years in collecting the information for chlorhydric, nitric and acetic acids.  The methods of procedure followed were those described in the nitrate of soda paper mentioned above.  The results obtained are given in the accompanying tables.  They cannot be as precise as those for sulphuric acid since the statistics of manufacture embrace all grades, while those for sulphuric acid were so returned that they could be reduced to a common standard.  They are believed  to represent the best obtainable results and have been so accepted by the several manufacturers to whom they have been submitted.

## TABLE II

### CONSUMPTION OF NITRIC ACID

| PRODUCTION | 1900 Pounds 63,084,722 | 1905 Pounds 108,380,387 |
|---|---|---|
| *Consumption* | 1900 *Pounds* | 1905 *Pounds* |
| Dyestuffs. ... ... ..   . . ..... ...... | 1,703,160 | 663,585 |
| Explosives....... | 35,353,600 | 82,676,800 |
| Fine chemicals...   .   .   .   .  . .  .. | 183,667 | 1,505,870 |
| General chemicals ....   .   .   .   .   .  ...  | 353,014 | 4,256,111 |
| Refining metals...     . . . .   .  . . ...  | 8,000,000 | 3,000,000 |
| Parting metals. ..  . ....  .. .. ..   . . ..| 10,221,786 | 6,810,273 |
| Plastics.......  ...    .   .   .   .   ....| 2,971,469 | 4,710.451 |
| All other uses ....  . ....  .  . .....  ..| 4,297,826 | 4,757,297 |

## TABLE III

### CONSUMPTION OF ACETIC ACID

| PRODUCTION | 1900 Pounds 29,506,021 | 1905 Pounds 27,875,222 |
|---|---|---|
| *Consumption* | 1900 *Pounds* | 1905 *Pounds* |
| Dyestuffs...... | 7,000,000 | 4,000,000 |
| Lead acetate... | 1,056,584 | 979,513 |
| Paper making.. .. | 8,000,000 | 7,000,000 |
| Textiles........... | 8,000,000 | 10,000,000 |
| White lead..... | 3,349,809 | 3,980,150 |
| All other uses........... | 2,099,628 | 1,915,559 |

# ABSTRACTS

GEODESY.—*Report of the Superintendent of the Coast and Geodetic Survey, showing the progress of the work from July 1, 1909, to June 30, 1910.* 454 pp., 4 maps and 5 progress sketches in pocket. 1911.

The administrative portion of this report recounts briefly the progress of work in field and office for the fiscal year ending June 30, 1910, covering the coasts under the jurisdiction of the United States. It also reports the progress made in surveying and marking the United States and Canada Boundary and the Alaska Boundary, under the direction of the Superintendent as United States Commissioner. Observations to determine the relative force of gravity at 27 stations in 14 States form an important contribution to the gravitation survey of the country. The magnetic survey was extended by making observations at 238 stations on land and at numerous stations at sea. Continuous observations with self-registering instruments were obtained at five magnetic observatories widely distributed over the country. Records of tidal changes were obtained at 15 widely separated stations.

A notable event of the year was the completion, in the instrument shop of the Survey, of a tide predicting machine, elsewhere described in this journal.

The report refers to the important contribution to the science of Geodesy made by the Survey in publications entitled "The Figure of the Earth and Isostasy from Measurements made in the United States" and "Supplementary Investigation in 1909 of the Figure of the Earth and Isostasy," which furnish a determination of the figure and size of the earth of a high grade of accuracy and which, by somewhat novel methods have established the fact that in and around the United States a condition of isostasy exists. This work was laid before the last General Conference of the International Geodetic Association and received formal

recognition when a famous geodesist, F. R. Helmert, arose and congratulated the Americans on having introduced a new epoch in geodesy.

Surveys were made of various uncharted localities in Alaska and excellent progress was made in surveying the waters of the Philippine Archipelago, more than 10 per cent of the estimated general coast line being covered during the year.

Important improvements were made in the construction and use of the long wire drag and its length was increased to 8,400 feet in open water.

The report announces that the policy of orienting charts with the meridian adopted twenty years ago will be continued and a definite programme followed of eliminating the old-style charts and replacing them with a smaller number on the mercator projection. The report is supplemented by six appendixes. Details of field and office operations are given in Appendixes 1 and 2. Appendixes 3–6 are abstracted separately. ISAAC WINSTON.

GEODESY.—*Primary base lines at Stanton, Texas and Deming, New Mexico.* WILLIAM BOWIE. App. No. 4, Rept. Coast and Geodetic Survey for 1910. Pp. 143–171, 5 figs. 1911.

Nickel-steel or invar tapes were adopted by the Coast and Geodetic Survey for the measurement of primary bases in 1906. (See Appendix 4, Report for 1907.) The first primary bases measured in the United States with invar tapes alone are those at Stanton, Tex., and Deming, N. M., in the Texas-California arc of primary triangulation in 1909 and 1910 respectively.

The two bases in question have lengths of 13.2 and 15.5 kilometers. The cost of measuring on the field was $56 per kilometer on the Stanton Base and $39 per kilometer on the Deming Base. Work on the Stanton Base required 17 days, and on the Deming Base 13 days. Measurements with the tape (50-meter) were made on 6 days at Stanton and 3 days at Deming, nearly all in daylight. The probable errors of the resulting lengths are 1/2,561,00 for the Stanton Base and 1/1,961,000 for the Deming Base. These are comparable with those obtained with the best base bars.

A new and very much lighter form of tape stretcher was used on these bases. On the Deming Base five supports were used for each tape length. With this number wind caused little or no trouble. No standardizations were made in the field. Those made at the Bureau of Standards before and after the measurement of each base showed that no one tape changed in length as much as 1/400,000. W. B.

GEODESY.—*Triangulation in California, Part II.*   C. R. DUVALL
and A. L. BALDWIN.   App. No. 5, Rept. Coast and Geodetic
Survey for 1910.   Pp. 173–429.   40 illus.   1911.

The geographic positions on the United States Standard Datum, of
triangulation points between Monterey Bay and Trinidad Head, Cali-
fornia, are given with all available descriptions of stations, and 40
sketches, together with a complete index.

The results of the primary, secondary and tertiary triangulation of
1906–07, executed principally to determine the effect of the earthquake
of 1906 on the old triangulation, are here published in full for the first
time.   Along with the newly determined position of each of the 61 old
points is given the position resulting from observations made before the
earthquake.   For a number of the old points it was possible to compute
separately the observations made before the earthquake of 1868, and for
these the three corresponding positions are placed together.   A compari-
son of these positions and a discussion of the corresponding displacement
was published in Appendix No. 3, Coast and Geodetic Survey Report
for 1907.   ("The Earth Movements in the California Earthquake of
1906," by J. F. Hayford and A. L. Baldwin.)              C. R. D.

GEODESY.—*The measurement of the flexure of pendulum supports with
the interferometer.*   W. H. BURGER.   App. No. 6, Rept. Coast
and Geodetic Survey for 1910.   Pp. 431–449.   5 figs.   1911.

The interferometer was adopted by the Coast and Geodetic Survey
for determining the flexure of the pendulum supports in 1907.   Pre-
liminary investigations were made by the author under the direction of
Mr. John F. Hayford with apparatus designed and constructed in the
instrument division of the Survey, under the immediate direction of
Mr. E. G. Fischer.   The instrument and methods are here described and
illustrated in sufficient detail to enable one to use them successfully.

This interferometer is a modified form of the one described in "Light
Waves and Their Uses," by A. A. Michelson.   It has given excellent
results at more than sixty field stations in the United States during the
past three years and at the base station at the Survey office, while the
pendulums were being restandardized.   This is believed to be the first
time that the flexure of the pendulum support has been determined satis-
factorily at field stations by this method.          WILLIAM BOWIE.

METEOROLOGY.—*Some causes of variation in the polarization of sky-light.* HERBERT H. KIMBALL, Weather Bureau. Journal of the Franklin Institute, April, 1911.

A summary is given of the observations made by the author in Washington between December, 1905, and May, 1910, and at various other stations of the Weather Bureau between July and October, 1910. It treats mainly of the relation of sky polarization to the meteorological conditions, with special reference to atmospheric transmissibility for solar rays. Most of the observations have been made in connection with pyrheliometric measurements of the intensity of solar radiation.

Accepting Rayleigh's theory that the polarized component of sky light is due to the scattering of the solar rays by very small particles, p.incipally the gas molecules of the atmosphere, it follows that a depletion of the solar rays due to scattering by large particles, such as dust, smoke, and water drops, should be accompanied by a decrease in the percentage of polarization. The observations show that this is the case, but that loss of solar radiation intensity due to absorption by aqueous vapor has no effect upon the polarization.

When air currents of different temperatures, or different degrees of saturation, and, in consequence, of different densities, are in juxtaposition, discontinuous surfaces are formed which reflect and disperse light incident upon them, resulting in a diminution of both the intensity of the solar radiation and the polarization of sky light as measured at the surface of the earth. The observations show that such conditions are usually followed by cloudiness and rain. It would therefore seem that a measurement of the polarization of sky light should give an early indication of any disturbance that may exist in the atmosphere. This would probably be the case were it not for the fact that sky polarization is modified by the amount of light reflected from the surface of the earth and from clouds, and also from dust and haze in the lower layers of the atmosphere.

The distance of the neutral points of Arago and Babinet from the anti-solar point and the sun, respectively, increase as the percentage of polarized light decreases. Since these distances may best be measured when the sun is just below the horizon, the irregularities due to reflection from the surface of the earth may be largely eliminated. However, since pyrheliometric measurements are only influenced by atmospheric conditions along the path of the incident solar beam, they are believed to offer a more promising index to atmospheric conditions than do any form of polarization observations. H. H. K.

METEOROLOGY.—*Levels of maximum and minimum cloudiness.* W. J. HUMPHREYS. Bulletin of the Mount Weather Observatory, 4. 1911.

The formation of fogs is caused mainly by the cooling of the surface of the earth through radiation, and hence the surface of the earth itself is one level of maximum condensation. The next level of maximum condensation is that of the cumulus cloud, and is limited in elevation by the vertical temperature gradient of the atmosphere. The decrease of temperature with elevation for the first three kilometers usually is far less than the adiabatic rate. Hence, under these conditions, convection can not extend very high, and therefore cumulus clouds commonly are phenomena of the lower atmosphere and of frequent occurrence. The next and only other level of maximum condensation is just beneath the isothermal region where the cirrus cloud prevails. Since the temperature at this elevation ceases to decrease with altitude therefore it is the limit of vertical convection, and any clouds brought to this level by long continued storms must spread out and not go up higher. The limit to convection and the swift winds of the upper cloud region spread the cirri over extensive areas, and hence they are more frequently seen than are those of the next lower levels that are more limited in extent.

At middle latitudes the levels of maximum condensation are, roughly: (1) *Fog level,* surface of the earth or water. (2) *Cumulus level,* 1 to 2 kilometers above the surface. (3) *Cirrus level,* 8 to 10 kilometers above the surface.

The corresponding approximate levels, or, preferably, regions of minimum condensation, are: (1) *Scud region,* 100 to 300 meters elevation. (2) *Alto-stratus region,* chiefly 4 to 6 kilometers above the surface. (3) *Isothermal region,* usually 11 kilometers or more above the surface.                                             W. J. H.

METEOROLOGY.—*Origin of the permanent ocean highs.* W. J. HUMPHREYS. Bulletin of the Mount Weather Observatory, 4. 1911.

The circulation of the atmosphere between the warm equatorial and the cold polar regions, together with the rotation of the earth, causes the prevailing winds at higher latitudes than about 33° to blow from west to east, and the tropical winds to blow from east to west. The former have an angular velocity about the axis of the earth greater than that of the earth itself, and therefore press up toward the equator, while the latter have a smaller angular velocity than the earth and conse-

quently tend to slide down toward the pole. Hence there are two belts of high barometric pressure surrounding the earth; one at about 32° S, and the other about the same latitude north. Both are well marked on the oceans, but, owing to great temperature variations, are practically obliterated over continents.

But even on the oceans the belts are not uniform. The northern belt has one region of maximum pressure, with closed isobars, just west of southern California, and another in the eastern Atlantic. The southern belt has three regions of maximum pressure; one just west of Chile, another west of southern Africa, and a third west of Australia. Each of these five regions of maximum pressure is essentially permanent, accompanied by fair weather, and surrounded by gentle anticyclonic winds.

At each of the five places of maximum barometric pressure, but nowhere else, the belts of high pressure are crossed by cold ocean currents. These pressure maxima, therefore, are due to the combined influence of the mechanical action of the oppositely directed winds north and south of them and to the low temperature of the cold ocean currents, and are located where the sum of the two influences has its maximum values.

The original paper contains several explanatory figures.     W. J. H.

METEOROLOGY.—*On the relation between atmospheric pressure and wind.* J. W. SANDSTRÖM. Bulletin of the Mount Weather Observatory, 3: 275–303. 1911.

A difference in barometric pressure between two neighboring places at the same level necessarily must start the wind blowing from the place of higher towards the place of lower pressure. But the direction of flow is modified by the rotation of the earth, and by frictional resistance. There are, then, three forces acting on a moving mass of air. A gravitational force proportional to and in the direction of the barometric gradient, (2) a force, clockwise in the northern hemisphere, at right angles to the instantaneous direction of the wind and proportional to the sine of the latitude, (3) a frictional resistance numerically equal and opposite in direction to the resultant of the other two.

On applying these facts to special cases the friction is found to be divisible into two portions, one of which is that of the wind on the surface of the earth, and the other that between the wind and the upper currents of air, which usually differ from the surface winds both in direction and speed. The author also shows how these forces may so combine as to cause the wind to follow a sinuous path.

The original paper is abundantly illustrated by meteorological charts of northern Europe.     W. J. HUMPHREYS.

TERRESTRIAL MAGNETISM.—*Results of magnetic observations made by the Coast and Geodetic Survey between July 1, 1909, and June 30, 1910.* R. L. FARIS. App. No. 3, Rept. for 1910, pp. 71–141. 1911.

This publication contains the results of magnetic observations made on land and at sea by the Coast and Geodetic Survey in the prosecution of the magnetic survey of the United States and outlying territories during the fiscal year ended June 30, 1910, including the determinations of the magnetic elements in 39 States and Territories. The results on land are tabulated by States and in the order of increasing latitudes of the stations. During the year observations were made at seventy-five (75) old stations to ascertain the secular change of the magnetic elements. Results of observations on the Atlantic and Pacific oceans and in the Philippines are grouped in separate tables. The latter portion of the report is devoted to the descriptions of land stations, including their permanent markings and true bearings from them to permanent objects, which are of use to local surveyors, especially where true meridian lines were established in conjunction with the magnetic work. R. L. F.

ELECTRICITY.—*The electrical conductivity of commercial copper.* F. A. WOLFF and J. H. DELLINGER. Bulletin Bureau of Standards, 7: 103–126. 1911.

A reliable average value for the conductivity of the copper furnished for electrical uses was desired by the American Institute of Electrical Engineers, to be used as the basis of new tables, to replace their old *Copper Wire Table* of 1893. The Bureau of Standards was asked to obtain the data, and copper samples from representative sources were investigated. Besides the samples measured extensive data were obtained from a large manufacturing company. The mean of the data, representing tests on more than 100,000,000 pounds of copper, was practically the same as the value previously assumed for the resistivity of *annealed* copper, in the preparation of wire tables and in the expression of per cent conductivity, etc., viz., *0.153022 ohm per meter-gram at 20° C.* This value is to be called the "Annealed Copper Standard."

The conductivity of hard-drawn wire of about 2 mm. diameter was found to be less than the conductivity of annealed wires by a mean value of 2.7 per cent. The difference between the conductivity of annealed and hard-drawn wires increases as the diameter decreases. The highest conductivity found was that of a wire drawn directly from a mass of native lake copper, viz., 101.71 per cent of the conductivity of the

'Annealed Copper Standard." The advantages of ohms per meter-gram as a unit of resistivity are stated. The desirability of an international standard of copper conductivity is urged.            J. H. D.

ELECTRICITY.—*The temperature coefficient of resistance of copper.* J. H. DELLINGER. Bulletin Bureau of Standards, 7: 71–101. 1911. Abstracted in the Journal of the Franklin Institute, 170: 243. 1910.

Standard values for the temperature coefficient of copper have varied greatly, and anaccurately determined value on representative samples was needed. Samples were investigated from 14 of the leading copper refiners and wire manufacturers in the United States, Germany, France, and Austria. The measurements were of especially high relative accuracy, as the wires were all compared against a copper auxiliary wire in the same oil bath. The principal result was the discovery of a proportional relation between conductivity and temperature coefficient, which holds substantially for samples chemically different, and holds within the errors of measurement for differences in conductivity due to differences in hardness. The change of resistivity per degree C. of a sample of copper is 0.000598 ohm per meter-gram or 0.00683 micro-ohm per centimeter cube, these constants holding for any temperature of reference and any sample of copper.

Bending and twisting a wire produce no material change in the temperature coefficient, although they increase the resistance. It may therefore be assumed with greater confidence than heretofore that the temperature coefficient of a copper wire is not changed by winding. In virtue of the proportionality between temperature coefficient and conductivity, the measurement of temperature coefficient may in certain cases be substituted for the direct measurement of conductivity.

The relation of resistance to temperature was found to be linear, for the temperatures investigated, 10° C. to 100°C. If this relation actually held continuously down to zero resistance, there would be a set of different temperatures, all higher than −273°C., at which the resistances of copper samples of various conductivities would vanish, and these "inferred absolute zeros" of resistance are sometimes used as an aid in remembering the temperature coefficient. But this investigation indicated nothing of the actual resistance of copper at very low or very high temperatures.

The proportionality between temperature coefficient and conductivity has been confirmed by results obtained at the Reichsanstalt.     J. H. D.

ELECTRICITY.—*A device for measuring the torque of electrical instruments.* P. G. AGNEW. Bulletin Bureau of Standards, 7: 45–48. 1911.

The device consists essentially of a dynamometer of the pendulum type. A needle is attached to the bob of the pendulum to serve as a pointer which swings closely over a scale consisting of 153 concentric circles engraved on the concave surface of a very shallow spherical bowl of a radius of curvature of one meter. The bob is suspended by a silk fiber at the center of curvature of this scale, which reads tangents of angles directly, the divisions being approximately 1 mm. and hence indicating angles whose tangents are 0.001, 0.002, etc. The force to be measured (always horizontal) is transmitted to the bob by a second fiber attached at its center of mass. The force in grams is then equal to the product of the weight of the bob into the number of divisions deflection. The range may be changed by attaching extra weights to the bob.

In measuing the torque of a deflection instrument—for example a voltmeter—the horizontal thread is fastened to the pointer at a convenient distance from the pivot and the voltmeter moved horizontally until the desired deflection is produced. We then have

Torque = arm × weight × 0.001 × reading in divisions.

In the case of a watthour meter it is necessary only to attach the thread to the edge of the disk, apply current and voltage to the meter, and allow the thread to wind upon the disk as far as it will. Under proper conditions an accuracy of 0.1 per cent may be obtained. The torques of some types of instruments have been found to range as follows: D. C. voltmeter 0.3 to 2.1 gram-cm.; D. C. ammeters 0.2 to 0.9 gram-cm.; A. C. watthour meters 3.0 to 7.8 gram-cm.          P. G. A.

RADIO-TELEGRAPHY.—*Quantitative experiments in long distance radio-telegraphy.* L. W. AUSTIN, U. S. Naval Wireless Telegraphic Laboratory. Bulletin Bureau of Standards, 7: 315–363. 1911.

The U. S. naval wireless laboratory during the winter 1909–1910 and the spring and summer of 1910 carried on quantitative measurements on the relation between the currents in the sending and receiving radiotelegraphic antennas. This work was taken up in connection with the testing of the wireless set at the Brant Rock station and those of the scout cruisers *Birmingham* and *Salem*. The Brant Rock station devel-

oped 60 kw. Its antenna was an umbrella 420 feet at top, about 170 feet at bottom with a capacity of 0.0073 microfarad. The scouts' sets were of 10 k.w. and their antennas were flat-topped, 130 feet high, with a capacity of 0.0018 microfarad. During a part of the test this was increased to 0.0025 by extensions slanting downward fore and aft of the regular antenna. The chief wave lengths used were 1500 meters and 3750 meters on the part of Brant Rock, and 1000 meters and 3750 meters on the ships.

In the July, 1910, test which was considered the most reliable the measurements were carried on up to nearly 900 nautical miles between the ships and to about 1200 miles between Brant Rock and the *Birmingham*.

The receiving measurements for the shorter distances were made in part by means of thermoelements in the antenna. At the greater distances the method of telephone shunt readings in connection with the electrolytic detector was used, the value of the received antenna current being derived from the shunt reading by means of comparison readings taken on a thermoelement in the antenna at the shorter distances.

In addition to these measurements already mentioned subsidiary observations were made between Brant Rock and a small station 11 miles away on the effect of height of a flat top antenna on sending and receiving and also on the effect of wave length.

The results are briefly as follows:

(a) Over salt water the electrical waves decrease in intensity in proportion to the distance as found by Duddell and Taylor. In addition they are subject to an absorption which varies with the wave length and which may be expressed mathematically by the term $e^{-Ad}$.

The complete expression for the received current is then

$$(1) \quad I_R = \frac{K}{d} e^{-Ad}$$

where $I_R$ is the received antenna current, d the distance, and K and A constants.

This is true in general for day transmission. The absorption at night is entirely irregular varying from zero to the day value, but is on an average much less during the winter than in summer. The great variations in night absorption make useless all attempts to judge the quality of wireless apparatus from night distances. For this purpose only observations on the average day range have any value. Variations also appear to occur during the daytime, but these are probably in general

small. (b) The received antenna currents between two stations are proportional to the product of the heights of the sending and receiving antennas and inversely proportional to the wave length, provided the antenna resistances remain constant. (c) Taking account of the influence of antenna height and wave length equation (1) may be extended and a general day transmission formula written as follows

$$(2) \quad I_R = 4.25 \frac{I_s h_1 h_2}{\lambda d} e^{-\frac{0.0015\ d}{\sqrt{\lambda}}}$$

When $I_s$ is the sending antenna current, h antenna height and $\lambda$ the wave length. The currents are given in amperes and all lengths in kilometers. From this it would appear that it is advisable to rate stations according to the magnitude of the antenna current, or perhaps better, according to the product of the current into the height. L. W. A.

CHEMISTRY.—*The behavior of high-boiling mineral oils on heating in the air.* C. E. WATERS. Bulletin Bureau of Standards, 7, 365–376, 1911. Journal of Industrial and Engineering Chemistry, 3: 233. 1911.

The oils were heated to 250° for three hours in Erlenmeyer flasks which were placed in a special air-bath so arranged as to secure free diffusion of air into them, as well as to allow the escape of volatile portions of the oils. After cooling, the contents were diluted with petroleum ether and next day the insoluble "asphalt" was filtered off and weighed. The insoluble matter was shown to be an oxidation product. The amount formed was apparently independent of the amount of oil evaporated. The latter, and also the amount of varnish-like coating on the walls of the flasks, varied widely, but the amount of insoluble matter was fairly constant.

There seemed to be some evidence of catalytic action which influenced the amount of insoluble and "varnish" formed. These were both greater in amount when a second lot of oil was heated in a flask which had not been cleaned after one heating.

Three different oils were heated also in tubes of the same dimensions made of glass, brass, chrome-vanadium steel, vanadium steel, cold-rolled steel, cast iron and a steel containing 0.8 per cent carbon. For two of the oils the percentages of insoluble formed were about the same in all of the tubes, except those of brass, where the amount was much greater. The third oil yielded less insoluble in the brass tubes than in those of glass, and very much greater amounts in the chrome-vanadium

steel tubes than in any of the others. This oil contained approximately 0.5 per cent fatty oil, while the other two were straight mineral oils.

C. E. W.

CHEMISTRY.—*The determination of manganese in vanadium and chrome-vanadium steels.* J. R. CAIN. Journal of Industrial and Engineering Chemistry, July, 1911.

The bismuthate method for manganese gives high results in vanadium or chrome-vanadium steels because some of the chromium and all of the vanadium are also oxidized and react with the ferrous solution used to reduce the permanganic acid. The Ford-Williams method gives high results because of occlusion of chromic acid by the precipitated manganese dioxide. The present method eliminates these sources of error by precipitating the chromium and vanadium out of a sulphuric acid solution of the steel by cadmium carbonate[1] and determining manganese in the filtrate by the bismuthate method after adding nitric acid.

J. R. C.

CHEMISTRY.—*The determination of vanadium in vanadium and chrome-vanadium steels.* J. R. CAIN. Bulletin Bureau of Standards, 7: 377, 1911; Journal Industrial and Engineering Chemistry, 3: July, 1911.

Various errors in the usual methods for determining vanadium in steel are pointed out and in a few cases methods for correcting or eliminating these are indicated. A new method based on precipitation of the vanadium by cadmium carbonate followed by electrolysis, reduction and titration, is described.

J. R. C.

ELECTROCHEMISTRY.—*The relation of surface action to electrochemistry.* HARRISON E. PATTEN, Bureau of Soils. Transactions of the American Electrochemical Society, 19. 1911.

A mathematical and illustrated treatment which may be summarized as: (1) A definition of surface tension as the first derivative of surface energy with respect to surface change. (2) A consideration of the general equations of surface changes following the treatment given by J. Willard Gibbs. (3) An extension of these equations with the assistance of a cyclic process to surfaces having an electric charge. (4) The appli-

[1] Jour. Ind. and Eng. Chem., 3: July, 1911; also Bull. Bur. Standards, 7: 377. 1911.

cation of the general equation developed in the third section to electro-capillary phenomena, to migration of suspended particles, and to electric osmose. (5) The relation of absorption phenomena to electro-capillary phenomena, to settling of suspensions, to formation of electrolytic deposits, and to the behavior of disperse systems in general.

H. E. P.

AGRICULTURAL CHEMISTRY.—*The color of soils.* W. O. Robinson and W. J. McCaughey. Bulletin Bureau of Soils, No. 79. Pp. 29. May, 1911.

This bulletin treats of the causes of difference in color, particularly of the red and yellow soils. It is concluded from the results of the iron determinations and the mechanical analysis of twenty typical red and yellow soils that the color is due to a colored film, mainly of iron and aluminum oxides and organic matter, surrounding the soil particles. A thin film gives a yellow color and a thick film a red color. Theoretical considerations indicate that the iron oxide in various soils must be in nearly the same condition of hydration. Mineralogical examination shows that in general the minerals in the red soils have been subject to more weathering than those of the yellow soils. Red soils are in general older than yellow soils, and certain chemical characteristics show them to be better drained. W. O. R. and W. J. McC.

AGRICULTURAL CHEMISTRY.—*The solubility of lime in aqueous solutions of sugar and glycerol.* F. K. Cameron and H. E. Patten, Bureau of Soils. Journal of Physical Chemistry, 15: 67. 1911.

(1) Solubility isotherms for lime in solutions of sugar and of glycerol at 25° have been determined by direct analysis of the liquid phases. (2) The solid phase in the system lime-sugar-water is one of a series of solid solutions, with calcium hydroxide a limiting case. (3) The solid phase in the system lime-glycerol-water at 25° is always calcium hydroxide. (4) The increase in solubility of lime in aqueous solutions of glycerol over that in pure water is directly proportional to the concentration of glycerol. F. K. C. and H. E. P.

AGRICULTURAL CHEMISTRY.—*The theoretical basis for the use of commercial fertilizers.* Frank K. Cameron. Journal of Industrial and Engineering Chemistry, 3: No. 3, March, 1911.

Abstract of remarks made before the Division of Fertilizer Chemists

at the Minneapolis meeting of the American Chemical Society. It was pointed out that soils behave as individuals, owing to the number and interdependence of the properties of the soil mass and its individual components. Crop production, therefore, is the result of many factors, natural and artificial, but all mutually dependent. Each of the artificial methods of control, tillage, crop rotation, and fertilization, affects all the factors; consequently, no simple theory of fertilizer action can satisfactorily explain the facts. With intensive methods of cultivation, fertilizers are effective on all kinds of soils, more so on the naturally better soils. Materials other than those containing the traditional plant foods may become valuable fertilizers if they satisfy commercial requirements.                                                      F. K. C.

AGRICULTURAL CHEMISTRY.—*Effect of a second solute in adsorption by soils and in leaching of soluble salts from soils.* HARRISON E. PATTEN. Journal of Physical Chemistry, 15. 1911.

A higher concentration of phosphates may be obtained when weak solutions of salts ordinarily used as soil amendments (potassium chloride, potassium sulphate, potassium and sodium nitrates, or potassium carbonate) are passed through the soil than can be obtained by the use of distilled water alone. This effect is not simply a question of the "solubility" of phosphate in water or in the solutions used for percolation, since the volume of liquid held in contact with the soil material is in all cases far greater than that required to dissolve the small amounts of phosphates and of other salts present. The effect is evidently due to a disturbance of the equilibrium between the soluble material retained by the soil and the soil solution. This disturbance having been produced the soil system tends to readjust itself, giving a *very roughly* steady value for the concentration of the leachings with respect to phosphate.

The bearing of this on the use of soil amendments is that it opens questions as to the actual functions of different salts when added to promote plant growth. It appears possible that the addition of, e.g., a nitrate or a chloride to the soil may benefit a plant by liberating phosphate, as well as by the addition of the salt itself for plant use. In addition must be considered the effects of the liberated phosphates and of the added soil amendment upon the physical structure and condition of the soil.                                                      H. E. P.

AGRICULTURAL CHEMISTRY.—*The effect of moisture and of solutions upon the electric conductivity of soils.* R. O. E. Davis. Transactions of the American Electrochemical Society, 17: 391–403. 1911.

Experiments on the conductivity of several types of soil under various conditions are described. The relation of conductivity of a soil to the corrosion of iron is pointed out. From the measurements of soil resistivity the conclusions are drawn: (1) That in the dry condition the soil offers a high resistance to the passage of the electric current. (2) That at a depth of two feet or more the conductivity remains roughly constant for a given soil type and soil area. (3) That the conductivity of soils saturated with water increases directly as the amount of salt in solution increases; below saturation, the resistivity increases almost in proportion to the surface area of the soil, at saturation and beyond, the surface area does not exert so much influence. (4) That humus decreases the conductivity of a soil.

A sandy soil will probably afford least electrolyte, and clay soil most, due mainly to the state of physical division of the soil. It would be possible to roughly calculate the electrolysis produced by a given potential difference between two points in the soil. R. O. E. D.

MINERALOGY.—*Die chemische Zusammensetzung von Jamesonit und Warrenit.* W. T. Schaller. Zeitschr. Kryst. Mineral, 49: 562–565. 1911.

From a review of the literature it is concluded that the formula for jamesonite is $4PbS.FeS.3Sb_2S$, while warrenite is a mixture of jamesonite and zinckenite. W. T. S.

MINERALOGY.—*An occurrence of strüverite.* Frank L. Hess and R. C. Wells. American Chemical Journal, 31: 432–442. 1911.

The mineral here designated strüverite is one of a series containing $Ti O_2$, $Fe O$, $Ta_2 O_5$ and $Cb_2 O_5$, in variable proportions. At one end of the series is a group to which the name ilmenorutile is given, in which $Cb_2 O_5$ exceeds $Ta_2 O_5$. At the other end of the series is a group in which the $Ta_2 O_5$ exceeds the $Cb_2 O_5$ and of which the mineral described in the paper is the only representative known. In 1908 Prior and Zambonini[1] described a mineral with a nearly medial composition, which they called strüverite, and defined in such a way as to include

[1] On strüverite and its relation to ilmenorutile. Mineralog. Mag., 15: 78–89. 1908.

and anticipate the discovery of minerals in which $Ta_2O_5$ was in excess of $Cb_2O_5$. To avoid confusion the name is retained.

The mineral here described is found in considerable quantity as an original constituent of the Etta granite pegmatite dike near Keystone, South Dakota. It is black, opaque, and crystallizes in the rutile group of the tetragonal system. It occurs as individual crystals, the largest of which are 1.8 to 2 mm. across, by 5 mm. long, and in aggregates up to 16 mm. across. The analysis was made by decomposing the mineral with chlorine and sulphur monochloride, and separating the chlorides thus obtained by fractional sublimation. The analysis gives the formula Fe O. $(Ta, Cb)_2O_5$. 6 Ti $O_2$ with 49.1 per cent Ti $O_2$, 7.5 per cent Fe O, 35.7 per cent $Ta_2O_5$, 6.4 per cent $Cb_2O_5$ and 1.3 per cent Sn $O_2$ (probably replacing Ti $O_2$). R. C. W.

GEOLOGY.—*Geology and ore deposits of the Breckenridge district, Colorado.* F. L. RANSOME. Prof. Paper U. S. Geological Survey No. 75. Pp. 184, with maps, sections and illustrations. 1911.

The Breckenridge district is in Summit County, Colorado, 60 miles west-southwest of Denver. The fundamental rocks are granites and schists of pre-Cambrian age. The thick series of Paleozoic rocks present in the Leadville and Tenmile districts thins to the north and west and is not represented near Breckenridge, where the oldest sedimentary rocks, resting directly on the pre-Cambrian, are the red sandstones and shales of the "Wyoming" (Triassic?) formation. Apparently conformable above them is the Dakota, overlain in turn by a thick formation of dark hales which probably represent the Benton, Niobrara, and part of the Montana formations of the Upper Cretaceous. In the northern part of the district the Dakota rests on the pre-Cambrian. The sediments are intruded by monzonitic porphyries ranging in composition from siliceous quartz monzonite porphyry to hypersthene-bearing diorite porphyry. The Quarternary deposits may in part be divided into glacial accumulations of Pleistocene age and stream gravels of the recent epoch. There were two advances and retreats of the ice. The earlier is represented by terrace gravels and what has been called older hillside wash; the latter by moraines and low-level gravels or valley trains.

The principal fissures strike northeast and form a conjugate system. No single fissure is known to exceed 1700 feet in length and none was formed to the accompaniment of important structural displacement. The ore deposits may be grouped as (1) veins of the zinc-lead-silver-gold series, (2) stockworks and veins of the gold-silver-lead series, (3)

gold veins of Farncomb Hill, (4) veins in the pre-Cambrian rocks, (5) metasomatic replacements along bedding planes, and (6) gold-silver deposits in Dakota quartzite. The Breckenridge ores were deposited through the agency of thermal waters and gases given off from a solidifying monzonitic magma and perhaps coöperating with water of atmospheric or of less definitely assignable origin. Whether the metals in the ores came from the magma or from the rocks invaded by it is not known. The principal gaseous constituents of the magmatic waters were hydrogen sulphide and carbon dioxide.

The ores were probably deposited in early Tertiary time and were enriched throughout the later Tertiary. The character of the deposits is notably dependent on the kind of country rock.

Most of the mines show a decrease in the proportion of galena with augmented depth, which means in general a depreciation of the ore. Lead ores of shipping grade probably nowhere in the district extend to a depth of much more than 300 feet. The downward change in the character of the ores indicates enrichment. A large part of the galena in the district is believed to have been concentrated by downward-moving atmospheric water.

There are three general classes of gold placers—(1) the bench or high-level placers; (2) the deep or low-level placers; and (3) the gulch washings. The gulch washings were the first worked and yielded much gold to the pioneers in the district. The most noted placers of this group were on the slope of Farncomb Hill. The bench placers are in the terrace gravels and older hillside wash. They have been extensively worked in the past by hydraulic methods, but were not being exploited in 1909. They are generally of low grade. The deep placers, in the low-grade gravels, occupy the bottoms of the present valleys and are now being worked by dredging. The pay channels are from 180 to 400 feet wide and average locally up to about 50 cents a cubic yard; but much of the material does not yield 20 cents a yard.          F. L. R.

BOTANY.—*Crown-gall of plants: Its cause and remedy.* ERWIN F. SMITH, NELLIE A. BROWN and C. O. TOWNSEND. Bulletin Bureau of Plant Industry, Department of Agriculture, No. 213. Pp. 215, pls. 36. 1911. *Crown-gall and sarcoma.* ERWIN F. SMITH. Circular Bureau of Plant Industry No. 85. Pp. 4. June 20, 1911.

Bulletin 213 deals with a widely distributed and harmful disease of orchard trees and other plants. This disease is commonly known in the United States as crown-gall, but it may occur not only on the crowns of plants, but on roots and shoots.

The disease has been known for a long time, and under the supposition that it was infectious and injurious various States have made quarantine laws against it. The disease has been ascribed to various causes, without satisfactory proof, and many persons have been led to believe that it was not due to any organism. The experiments detailed in the Bulletin show clearly that the gall is due to bacteria and is infectious, being readily transmitted not only from plant to plant of the same kind, but also to many plants of widely different families. The Bulletin shows that the growth is not only of itself injurious to the plant, but also may form an open wound through which other parasites are likely to enter, such as the fungus of root rot, and the bacteria which cause blight of apples and pears.

The Bulletin recommends that the inspection laws now in force in the various States be continued and enforced. It shows what plants it is not advisable to use as a crop following a galled one. It describes the life history and cultural characters of the organism involved; points out the difficulties attending its isolation and identification; gives numerous illustrations showing the nature of the tumors produced and the time involved in their production when pure cultures of the organism were used; shows that the organism has a wide range of host plants, and that the overgrowths produced are in many ways anatomically and otherwise strikingly like those found in certain malignant animal tumors.

The bacteria causing these plant tumors are not abundant in the tissues, sometimes very rare; are hard to see and difficult to stain; they perish readily both in the tumor and in culture-media; are difficult to cultivate from the tissues unless one knows the technique; do not form abscess cavities after the manner of the tubercle diseases, but multiply in limited number within the tissues and apparently only inside the cells which their presence stimulates into rapid division. The disease forms secondary tumors readily, and on this account is cut out with difficulty.

The organism loses virulence easily both inside the tumors and in culture-media, and finally if the plants are not destroyed by it they seem to acquire a partial or complete immunity.

The Bulletin involves team work done by four people in the Department of Agriculture, covering a period of seven years and the total number of experiments involved amounts to thousands.

Circular No. 85 gives in outline the results of further studies on resemblances of crown-gall of plants to malignant animal tumors. Since Bulletin 213 was published it has been found that the primary tumors are connected to the secondary ones by means of a deep-seated strand of tumor tissue. This strand occurs in the inner wood or at the junction of wood and pith, and wedges apart the normal tissues of stem and leaves quite after the manner of a foreign body, giving rise in various places to the secondary tumors.

When the primary tumor occurs on a stem, secondary tumors frequently appear in the course of a few weeks or months at a considerable distance on leaves, and in this case the same thing happens as in metastasis of malignant animal tumors, viz., the structure of the secondary tumor is that of the primary tumor and not that of the tissue in which it is lodged. In other words, the leaf tumors of this derivation have the anatomy of the *stem*.

The bacteria occur within the multiplying tumor cells and it is through their action on the nucleus that these cells are compelled to divide and take on the abnormal rapidly multiplying tumor growth. The bacteria have been found (sparingly) in the secondary tumors and in the strands connecting these to the primary tumor. There is no reasonable doubt, therefore, that we have in this disease a type of cell multiplication closely parallel to that which occurs in malignant animal tumors.

Full details will be given in another bulletin as soon as the photomicrographic illustrations can be prepared.                    E. F. S.

FORESTRY.—*Windbreaks: their influence and value.* CARLOS G. BATES. Forest Service Bulletin No. 86. Pp. 106, with plates and diagrams. 1911.

Windbreaks may be used profitably in the middle west, the northern prairies, the lake states, the eastern states north of the forty-ninth parallel, the southwestern states, and in the fruit growing regions of the Pacific coast.

The distance at which the effect of a windbreak may be felt averages

twenty times its height, altho absolute protection of a crop such as corn, in a wind with a velocity of 50 miles an hour, can not be expected beyond a distance of from six to eight times the height of the windbreak. Partial protection is given over a distance of from twelve to fourteen times the height.

The efficiency of a windbreak in checking evaporation from the soil may, in extreme cases, amount to 70 per cent of the moisture ordinarily lost. Protection in this respect is appreciable for a distance equal to five times the height of the trees in the windward direction, and fifteen or twenty times the height leeward.

The effect of a windbreak upon temperature in the zone of its influence is much greater than is commonly supposed. The daily range of temperature in an area protected by a windbreak is nearly 9° F. greater than where the air circulates freely. The effect of the superheating of both air and soil in a protected zone is favorable to crops which must begin growth at a time when the heat is barely sufficient for germination. Corn and alfalfa are the field crops least affected by the shade from windbreaks.

Honey locust and osage orange are the trees adapted to windbreak planting which cast the heaviest shade. Cottonwood, maple, green ash, white cedar, and Scotch, Austrian, and white pine are those which cast the least.

The absorption of soil moisture by the roots in a windbreak may in the case of an orchard be appreciable, but need not result in real damage. Corn, oats, and wheat may suffer within 45 feet from the windbreak, but with care the effect is much less apparent. It may be greatly lessened by thorough cultivation of the soil near the trees, by planting tap rooted species in the windbreak, or by the use of seed crops next to the trees. There is little basis for the belief that windbreaks sap the fertility of the soil. The trees' use of soil moisture may, however, reduce the activity of the nitrifying bacteria and cause temporary sterility in the zone of root influence.

Cottonwood is the best tree for windbreaks in the middle west; Scotch pine, Norway pine, and Colorado blue spruce in the northern prairies; white pine in the lake and northeastern States; chestnut and yellow poplar in the central eastern States; osage orange in the southwest; eucalypts, Monterey cypress and Monterey pine in California; and poplars, willows, and cottonwoods in Washington and Oregon.

FINDLEY BURNS.

FORESTRY.—*Eucalypts in Florida*. RAPHAEL ZON. Forest Service
  Bulletin No. 87.   Pp. 47, with plates.   1911.

Next to southern California, Florida promises most for the growing of
eucalypts in the United States.   The region in Florida in which eucalypts
can be successfully grown may be roughly defined as the orange belt,
about 40 per cent of the total area of the State.   In all, about 16 species
of eucalypts are growing in Florida today.   Those which are especially
well adapted to the climate are *E. resinifera, rostrata, viminalis, robusta,*
and *tereticornis*.   The planting is still in the experimental stage.   If
the species of eucalypts which are adapted to Florida can be economically
grown on a large scale, and will yield durable ties, posts, and piles at an
age at which the native trees hardly reach sapling size, they will prove
of the great value to the State.   There are available for experiment large
areas in Dade, De Soto, Lee, Hillsboro, Pasco, Fernando, and Sumter
Counties at present, which are not in a high state of productivity.

<div align="right">FINDLEY BURNS.</div>

ZOÖLOGY.—*Anatomy and physiology of the wing-shell Atrina rigida.*
  BENJAMIN H. GRAVE, University of Wyoming.   Bulletin of the U. S.
  Bureau of Fisheries, **29**: 409–440, pls. 48–50, figs. 15.   1911.

This study establishes the following points:

1.   The arterial system of the two sides is not symmetrical.

2.   The venous system lacks the "sinus venosus" which is commonly
present in lamellibranchs and which receives the blood from all parts
of the body previous to entering the kidney.   This sinus or a substitute
for it is a necessary part of the mechanism described by Menegaux for
extruding the foot and other organs whose movement is due to blood
pressure.

3.   The blood which enters the gills must pass through a capillary
system before emerging again.

5.   There is no pallial line but the mantle is attached to the shell at
a single point just ventral to the adductor muscle.   As a consequence
the mantle can be withdrawn a considerable distance from the edge of the
shell.   After being contracted the mantle again reaches the edge by
creeping outward upon the shell.

6.   The spines on the outer surface of the shell are formed by little
tongues of the mantle which creep out into them during their growth
period.

7.   The mantle gland which Menegaux calls the "appendice" is
probably a "swab" for keeping the mantle free from dirt.

8. The kidney excretes vacuoles containing quantities of concretions, but little protoplasm and no nuclei are thrown off.

9. Each ganglion supplies a definite region of the body and there is little overlapping. Reflex arcs exist.

10. The otocyst is located in the end of the foot far from the pedal ganglion and is a variable structure, sometimes consisting of as many as eight lobes and sometimes of only one. In one instance three seprrate ciliated tubes connecting them with the outside were discovered. This indicates that they have arisen from three separate invaginations of the ectoderm. This is the first instance of this sort found in lamellibranchs above the protobranchia. E. M. SMITH.

CONCHOLOGY.—*Notes on California shells, II.* WM. H. DALL. National Museum. Nautilus, 24: 109–112. 1911.

Miscellaneous notes on species represented in the National Museum and in various California collections. *Bathytoma tremperiana, Modiolus diegensis* and *Pachyonia inæquale* var. *spiratum* are described as new. PAUL BARTSCH.

CONCHOLOGY.—*Notes on California shells, III.* WM. H. DALL. National Museum. Nautilus, 24: 124–127. 1911.

Miscellaneous notes on the distribution of many California species. PAUL BARTSCH.

CONCHOLOGY.—*Notes on Gundlachia and Ancylus.* WM. H. DALL. National Museum. American Naturalist, 45: 175–189. 1911.

Biological notes bearing on the validity and relationship of the two genera, illustrated by a series in the National Museum.
PAUL BARTSCH.

CONCHOLOGY.—*New species of shells from Bermuda.* WM. H. DALL and PAUL BARTSCH. Proceedings U. S. National Museum, 40: 277–288, pl. 38. 1911.

An account of species collected in Bermuda and of which a series is in the National Museum. The following are described as new and mostly figured. *Mitra haycocki, Columbella somersiana, Aclis bermudensis, Turbonilla (Careliopsis) bermudensis, T. (Strioturbonilla) peilei, T. (S.) haycocki, Cerithiopsis movilla, C. ara, C. pesa, C. vicola, C. io, Fissuridea bermudensis, Odostomia (Chrysallida) nioba,* and *Ischnochiton (Stenoplax) bermudensis.* A list of the species not new is also given which contains several not previously reported from Bermuda. P. B.

CONCHOLOGY.—*Description of new mollusks of the family Vitrinellidae from the west coast of America.* PAUL BARTSCH. Proceedings U. S. National Museum, **39**: 229–234, pls. 34–40. 1911.

The following new species are described and figured: *Cyclostrema baldridgei, miranda, adamsi; Circulus liriope* and *diomedeæ* and *Cyclostremella dalli.*                                                        P. B.

CONCHOLOGY.—*The recent and fossil mollusks of the genus Alabina from the west coast of America.* PAUL BARTSCH. Proceedings U. S. National Museum, **39**: 409–418, pls. 61–62. 1911.

This paper is a monograph of the genus *Alabina* in which all the species known from the west coast are described and figured. The following are new: *Alabina barbarensis, hamlini, phanea diomedeæ ignati, monicensis, tenuisculpta diegensis,* and *tenuisculpta phalacra.*

P. B.

FISHERIES.—*The migration of salmon in the Columbia River.* CHARLES WILSON GREENE. Bulletin of the Bureau of Fisheries, **29**: 129–148. Pls. 26–27. 1911.

On August 14, 1908, at the State fish hatchery at Chinook, Washington, there were liberated 25 chinook salmon, 16 silver salmon, and 18 steelheads which had been marked by means of an aluminum patent button clamped through the tail fin. Seventeen fish out of this total of 59 were retaken and reported, and upon their careers as indicated by place and date of capture are based the following conclusions, which, however, because of the preliminary nature and limited extent of the experiment, are presented as tentative: (1) Salmon may take from 30 to 40 days to pass through the brackish water within the limits of the fishing waters at the mouth of the Columbia River. (2) That salmon spend considerable time swimming back and forth in tide water during the acclimatization to fresh water is indicated (a) by the fact that two fishes were taken below the point at which they were marked, (b) by the corrosion of the aluminum marking buttons by salt water, and (c) by the long time spent by certain fishes in reaching the lower limits of fresh water. (3) When wholly within fresh water, the silver salmon and the steelhead make the migratory journey at an average speed of from 6 to $7\frac{1}{2}$ miles a day and probably more. (4) There is little evidence that the process of marking or that partial obstruction of the course by fishing gear does more than produce a temporary checking of the migratory journey.                                        E. M. SMITH.

FISHERIES.—*Condition and extent of the natural oyster beds of Delaware.* H. F. MOORE. Bureau of Fisheries Document 745. Pp. 30, 1 chart. 1911.

The State of Delaware, following the example of various other oyster producing States, recently solicited a Federal survey of her natural oyster grounds in Delaware Bay. Dr. Moore, representing the Bureau of Fisheries, was in charge of the work, which had for its specific purpose the accurate location and charting of the natural oyster beds and investigation of their present condition and productiveness.

Of the 16,435 acres (over 25 square miles) explored with sounding lines and chains, 2,144 acres were found to be included in areas of varying degrees of productiveness. These represented a total oyster content estimated after careful examination to be 189,035 bushels. Each bed is described and details of the examinations are tabulated to show dense, scattering, very scattering and depleted areas in each case, the number of each kind of oysters (seed and market) actually caught per square yard, and the estimated content per acre.

Tides, currents and salinity of the water were noted, as was also the presence of probability of enemies of the oyster. Of these the drill was found to be the most destructive in this region.

The chart accompanying the report is of large size and replete with data as to character of oyster growth, depths and character of bottom, in addition to accurate delineation of the oyster beds.    E. M. SMITH.

PHARMACOLOGY.—*The effects of a number of derivatives of choline and analogous compounds on the blood pressure.* REID HUNT and R. DE M. TAVEAU, Hygienic Laboratory, U. S. Public Health and Marine-Hospital Service. Bulletin of the Hygienic Laboratory, No. 73. 1911.

This bulletin discusses the methods of preparation and the physiological action of 79 compounds related to choline; most of them had not previously been made. Some of these substances have more pronounced effects upon the circulation than any drugs previously known and it is probable that some of them will ultimately prove of practical importance. The relation between the chemical constitution and the physiological action of the members of this group of compounds was studied as the basis for further work in the search for useful remedies.    R. H.

PHARMACOLOGY.—*Digitalis standardization and the variability of crude and of medicinal preparations.* WORTH HALE, Hygienic Laboratory, U. S. Public Health and Marine-Hospital Service. Bulletin of the Hygienic Laboratory, No. 74. 1911.

Digitalis is one of the most important drugs in the Pharmacopœia, but, unfortunately, it is of very variable activity; this bulletin discusses, in detail, some of the causes of this variability. The influence of the age of the leaves (whether of the first or second year growth), the methods of drying and preserving, and the effect of cultivation, are discussed; also the variations in the strength of official preparations, the relative strength of fluid ext acts and tinctures, and best methods of insuring preparations of uniform activity. A number of special preparations such as triturates, tablets, and certain proprietary preparations were also examined. W. H.

PHARMACOLOGY.—*Digest of comments on the Pharmacopœia of the United States of America (eighth decennial revision) and the National Formulary (third edition) for the calendar year ending December 31, 1908.* MURRAY GALT MOTTER and MARTIN I. WILBERT, Hygienic Laboratory, U. S. Public Health and Marine-Hospital Service. Bulletin of the Hygienic Laboratory, No. 75, 1911.

The present bulletin is the fourth of the series of "Digest of Comments" on the Pharmacopœia of the United States and the National Formulary, the two books recognized by the Food and Drugs Act of June 30, 1906, as the standard with reference to the identity, purity and strength of the medicaments therein described.

All of the available publications, containing matter of interest to the revisers of the Pharmacopœia and the National Formulary, have been reviewed and practical suggestions and references, bearing on the improvement of the two books as standards under the law, are presented in as concise a form as possible.

Apart from their use by the members of the several Committees of Revision these bulletins are of value as a résumé of current literature on the scope and content of the Pharmacopœia and the National Formulary, and on the nature, origin and uses of the various substances used in the treatment of disease.

Considerable space is given to the discussion of the possible development of international standards for potent medicaments, and the gradual compliance of foreign Pharmacopœias with the provisions of the treaty signed at Brussels in 1906 is noted. M. G. M.

BACTERIOLOGY.—*Abortive cases of poliomyelitis: an experimental demonstration of specific immune bodies in their blood-serum.* JOHN F. ANDERSON and WADE H. FROST, Hygienic Laboratory, U. S. Public Health and Marine-Hospital Service. Journal of the American Medical Association, 56: 663–667. 1911.

This paper gives the results of a series of experiments to demonstrate the existence of abortive cases of poliomyelitis or infant le paralysis by making use of the serum of recovered cases of this disease to neutralize the virus of poliomyelitis. It was found that the clinical diagnosis of abortive cases of poliomyelitis was confirmed by laboratory experiments in 66 per cent of the cases studied. These findings have a most significant bearing on the diagnosis and epidemiology of acute anterior poliomyelitis.                                                     J. F. A.

BACTERIOLOGY.—*Experimental measles in the monkey: a preliminary note.* JOHN F. ANDERSON and JOSEPH GOLDBERGER, Hygienic Laboratory, U. S. Public Health and Marine-Hospital Service. Public Health Reports, 25: 847. 1911. *Experimental measles in the monkey: a supplemental note.* JOHN F. ANDERSON and JOSEPH GOLDBERGER. Ibid. 25: 887. 1911. *The period of infectivity of the blood in measles.* JOHN F. ANDERSON and JOSEPH GOLDBERGER. Journal of the American Medical Association, 57: 113. 1911.

Previous to the appearance of these brief papers, various investigators had reported that the monkey was not susceptible to measles. The authors, however, have shown that the monkey is susceptible to measles by inoculation of the blood or of the nasal and buccal secretion from human cases of measles. Further, that when a well monkey is placed in the cage with a monkey suffering from measles the former contracts the disease after the usual incubation period. It is believed that the results reported in these papers mark an important advance in our knowledge of the etiology of measles. It s hoped that further work may definitely determine the cause of measles and the means of its transmission and methods by which the disease can be prevented.            J. F. A.

SANITATION.—*Sewage pollution of interstate and international waters, with special reference to the spread of typhoid fever. I.—Lake Erie and the Niagara river.* ALLAN J. MCLAUGHLIN, Hygienic Laboratory, U. S. Public Health and Marine-Hospital Service. Bulletin of the Hygienic Laboratory, No. 77. 1911.

This is the first of a series of papers which it is contemplated to present for publication on the problem as it affects certain international

and interstate waters.   The investigation was begun on the Great Lakes because of the industrial and commercial importance of the lake cities and the spread of typhoid fever by means of the enormous interstate traffic for which these cities are responsible.          A. J. McL.

ENGINEERING.—*The expansion and contraction of concrete while hardening.*  A. T. GOLDBECK, Office of Public Roads.  Proceedings of the American Society for Testing Materials, 11: 1911.

This paper presents the results of micrometer measurements taken on concrete while hardening.   The specimens were 8 inches by 8 inches in cross-section with a gage length of 50 inches.   They were mixed in different proportions, with varying percentages of water and were stored under different conditions of moisture.   Quantitative results of the shrinkage in air and expansion while moist are shown graphically, the initial measurements having been taken when the specimens were one day old and continued at regular intervals.          A. T. G.

ENGINEERING.—*Bituminous dust preventives and road binders.*  PREVOST HUBBARD, Office of Public Roads.  Yearbook of the Department of Agriculture, 1910.  1911.

The author, after mentioning bitumens as the most important class of materials employed as dust preventives and road binders, divides them into two main classes: (1) Native bitumens, (2) Artificial bitumens. The treatment of the former for the purpose of making them suitable for use on roads is briefly discussed, as is also the relative value of different bituminous distillates and residues.   This is followed by a classification of bituminous materials with regard to their value as "dust preventives" or as "road binders."   The conditions affecting the selection of material are briefly outlined, followed by a description of the two principal methods of application—the penetration method and the mixing method.   The author also briefly describes the character and method of application of rock asphalt and manufactured bituminous aggregates.          C. S. REEVE.

# PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

## WASHINGTON ACADEMY OF SCIENCES

At the 66th meeting, at the Cosmos Club, January 5, 1911, Dr. JOHN A. BRASHEAR delivered an address on *The contributions of photography to stellar research.*

The author discussed in a clear and charming manner many of the contributions that photography has made to our knowledge of astronomy and illustrated each with beautiful pictures.

The 67th meeting, at the Cosmos Club, 4:40 p.m., January 19, 1911, was for the transaction of routine business and the election of officers for the ensuing year, as follows: *President,* F. W. Clarke; *Non-resident Vice Presidents,* T. C. Chamberlin, H. F. Osborn; *Corresponding Secretary,* Frank Baker; *Recording Secretary,* W. J. Humphreys; *Treasurer,* A. L. Day; *Resident Vice Presidents,* nominated by the affiliated societies; Anthropological Society, Walter Hough; Archaeological, Mitchell Carroll; Biological, David White; Botanical, W. E. Safford; Chemical, H. W. Wiley; Engineers, M. O. Leighton; Entomological, A. D. Hopkins; Foresters, Gifford Pinchot; Geographic, Henry Gannett; Geological, A. H. Brooks; Medical, W. M. Barton; Historical, J. D. Morgan; Philosophical, Lyman J. Briggs.

At the 68th meeting, at the Cosmos Club, January 19, 1911, Dr. F. M. JAEGER, Professor of Chemistry in the University of Gröningen, Holland, spoke *On doubly-refracting liquids and the so-called liquid crystals.*

The subject of "liquid crystals" and "anisotropic liquids" is one of experimental research and also of theoretical speculation, and has a most important significance for both chemistry and physics, since it is fundamental to our theoretical ideas on the real nature of liquids.

When we ask ourselves how far it is right to speak of "liquid crystals, we can treat the question from two sides: First, as to how far liquids can exhibit properties that have seemed to be typical of "crystalline" matter; and second, to what degree crystals can share the characteristics of a "liquid" in the common sense of the word.

The typical property of crystalline matter is its anisotropy, or the rigorous dependence of the physical properties of crystals on the special direction in which those properties are observed. In most cases such media are *optically* anisotropic, a condition that insures the easiest and most certain detection and measurement of this property.

It is well known that true liquids can become birefringent under the

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influence of mechanical deformation, as demonstrated by Maxwell, Mach, de Metz, and others; under dielectric stress, as shown by Kerr, and also, according to Majorana, in strong magnetic fields.

In all these cases the common point is that the birefringence disappears always with the external forces which produced it—with most liq ids instantly, with some gradually. The time required for the birefringence to fall to the 1 e part of its original value has been defined by Maxwell as the "time of relaxation," and is directly proportional to the internal friction. The time of relaxation has never ·been found greater than one and one-half hours, and this is much reduced with a slight incre se of temperature.

It n ight be supposed that liquid crystals are only liquids of very long relaxation periods, but this view is not supported by accurate measurements of viscocity nor does it agree with the observed close analogy between the birefringent and the ordinary isotropic liquids. On the other hand, it is a well known fact that crystals can be plastic to any degree. In fact the possibility of deforming crystals without destroying them is of the highest practical importance in drawing and forging metals and their alloys as Ewing, Rosehain, and others, have demonstrated with the microscope. We might therefore ask what manner of substance is a crystal that shows such a high degree of plasticity?

Consider, for instance, the needle-like crystals that form on the carbon plates of exhausted Leclanché cells, and have the composition $ZnCl_2$ + $2NH_3$. These can be wound spirally around an ordinary lead pencil without breaking them or destroying their orthorhombic character. Experiment shows that they possess one or more systems of so-called "gliding planes" along which the molecules roll and glide, under the influence of feeble forces, incomparably more easily than along any other plane. The deformation of the crystal in these cases is called "singular deformation along gliding planes" and does not alter the internal structure. Exact investigations have shown that the original symmetry of the molecular aggregation remains wholly intact. A deformed crystal of barium bromide, for instance, will continue growing in its saturated solution and become a quite normal individual, which would be impossible if the molecular arrangement of the crystal had been modified during the deformation. Crystals may have a number of gliding planes; those of the Leclanché cells have six, situated in two different zones. Crystals can thus be deformed without alteration of their internal molecular structure, and this deformation can take place in several directions at the same time, and the crystals therefore be highly plastic.

Suppose we had a crystal of this kind whose molecules roll so easily along a number of such gliding planes that even a weak force like gravitation is sufficient to move them; it would be deformed under its own weight without any change of internal structure—the crystal would "flow." Looked at in this way the expression "fluid crystal" loses its seeming absurdity. Such crystals exist and are closely related to ordinary crystals from which they differ only in having a much smaller rate of recovery after deformation, and a preponderant surface tension.

Fluid crystals, like ordinary crystals, possess form, elasticity, surface tension and molecular vector forces. Presumably, therefore, a real distinction exists between these fluid crystals and the true "anisotropic liquids," like $p$-azoxyphenetol, for here no trace of form elasticity remains. The numerous transi ions of these latter and their whole physico-chemical behavior are quite analogous to those of fluid crystals, but their behavior under the microscope differs in so many respects from that of the true liquid crystals that their real nature is still enigmatic.

All substances showing the phenomena of fluid crystals, or anis tropic liquid phases, behave exactly like polymorphic substances. All the transition phenomena shown by these compounds during the gradual rise or fall of temperature of the system can be explained in just the same way as in the case of polymorphic substances undergoing a series of phase-transitions. Even the same two kinds of polymorphic transformations, the "enantiotropic" (reversible) and the "monotropic" (irreversible) are met with again here; and just as there are substances with two, three, four and more different solid polymorphic modifications, so there are substances which exhibit two, three, four or more liquid states. The liquid which appears last, or at the highest transition temperature, is always the isotropic one; the others are turbid-looking aggregations of fluid crystals, and notwithstanding the fact that they are stable at *lower* temperatures, the fluid crystals are often of *much lower* viscosity than the isotropic liquid. Fluid crystals are true homogeneous phases as has been proved in a number of ways.

All anisotropic liquid phases have a *turbid* appearance. They look as if they were emulsions like oil and water. However, this appearance of turbidity is not at all indicative of a close analogy to emulsions, but is a necessary consequence of the particular structure of these phases, for they are really aggregations of innumerable little fluid crystals each of which is completely transparent. These little crystals, like ordinary crystals, are birefringent, and when in great multitude and irregularly oriented must be turbid as a whole from the innumerable refractions and total reflections of the transmitted light at the boundaries between adjacent individuals.

It has been asked why liquid crystals do not flow together. Real liquids do so; but they possess no molecular *directive* force. On cooling, an isotropic liquid is transformed into an aggregation of liquid crystals and not into a single one, for the same reason that a molten substance never solidifies to one big solid crystal but always to a turbid aggregate made up of a great number of irregularly oriented crystals.

The strange and disturbing phenomena which are displayed by fluid crystals and in particular this misunderstood turbidity, have led some to suppose that these substances are not pure compounds but are mixtures of imperfectly miscible liquids. To be sure, liquid emulsions feebly depolarize transmitted light; but they can never account for the systematic variation of the enormously strong birefringence with the direction of transmission through these flowing bodies—a birefringence which is. in some cases, several times that of calcite. And there are many other

properties, such as pleochroism, magnetic induction, and discontinuous phase transition, which can not be explained in this way. In short numerous physico-chemical researches have proved beyond doubt that fluid crystals are simple homogeneous phases of well defined chemical compounds.

The lecture was accompanied by experiments and illustrated by a number of slides that made the speaker's meaning clear and his argument convincing.

At the 69th meeting, in the Cosmos Club, February 1, 1911, Dr. W. D. BANCROFT, Professor of Physical Chemistry, Cornell University, presented *A universal law*. Reported in *Science*, **33**: 436.   1911.

At the 70th meeting, in the National Museum, March 25, 1911, Dr. SVANTE ARRHENIUS, Director of the Nobel Institute, Stockholm, Sweden, spoke on *The atmospheres of the planets*.   Reported in *Science*, **33**: 632. 1911.

At the 71st meeting, in the Cosmos Club, March 30, 1911, Dr. VICTOR GOLDSCHMIDT, Professor of Mineralogy in the University of Heidelberg, Germany, lectured on *The nature of crystals*.   Reported in *Science*, **33**: 870.   1911.

At the 72d meeting, in the National Museum, April 18, 1911, SIR JOHN MURRAY delivered an illustrated address on *The ocean*.   Reported in *Science*, **33**: 870.   1911.

The 73d meeting was held on the steamer *Southland*, en route to the Dismal Swamp, April 28, 1911.   The following addresses were delivered: *Geography and geology of the Dismal Swamp*, E. W. SHAW; *Peat deposits*, C. A. DAVIS; *The forest types in the Dismal Swamp*, R. ZON; *Plant life in the Dismal Swamp*, F. V. COVILLE; *Ground animals of the swamp*, F. W. TRUE; *The birds of the swamp*, C. HART MERRIAM.   Reported in *Science*, **33**: 909.   1911.   W. J. HUMPHREYS, *Recording Secretary*.

PHYSICS.—*Note on graphic solutions of Wien's spectral equation.*   GEORGE K. BURGESS, Bureau of Standards.

The fundamental equation of optical pyrometry is that expressing Wien's law,

$$I_\lambda = C\lambda^{-5} e^{-c,\lambda T}$$

which we may consider from three points of view:

1. For the determination of the temperature $T_1$ or $T_2$ of a black body from observations on the corresponding intensities $I_1$ and $I_2$ of light of a given wave length:

$$\frac{\lambda}{c} ln \frac{I_1}{I_2} = \frac{1}{T_2} - \frac{1}{T_1} \dots\dots\dots\dots\dots\dots (1)$$

2. For the determination of the temperature $T$ of a substance whose absorption coefficient $A_\lambda$ (equal to $1 - R_\lambda$ where $R_\lambda$ is the reflecting power) for a given wave length $\lambda$ is known and whose apparent temperature is $S_\lambda$ as given by an optical pyrometer using light of the same wave length $\lambda$ :

$$\frac{\lambda}{c} ln A_\lambda = \frac{1}{T} - \frac{1}{S_\lambda} \dots\dots\dots\dots\dots\dots (2)$$

3. For the determination of the temperature of a black body from intensity observations at two wave lengths $\lambda_1$ and $\lambda_2$:

$$ln \frac{I_1}{I_2} = 5 ln \frac{\lambda_2}{\lambda_1} + \frac{c}{T}\left(\frac{1}{\lambda_2} - \frac{1}{\lambda_1}\right) \dots\dots\dots\dots (3)$$

The value of $c$ is a constant that has been determined as lying

between 14200 and 14700 when $\lambda$ is expressed in $\mu$ (0.001 mm.) and temperatures in centigrade absolute.

Equations (1) and (2) are identical in form and may be treated together. Equation (3) is of only limited interest in temperature
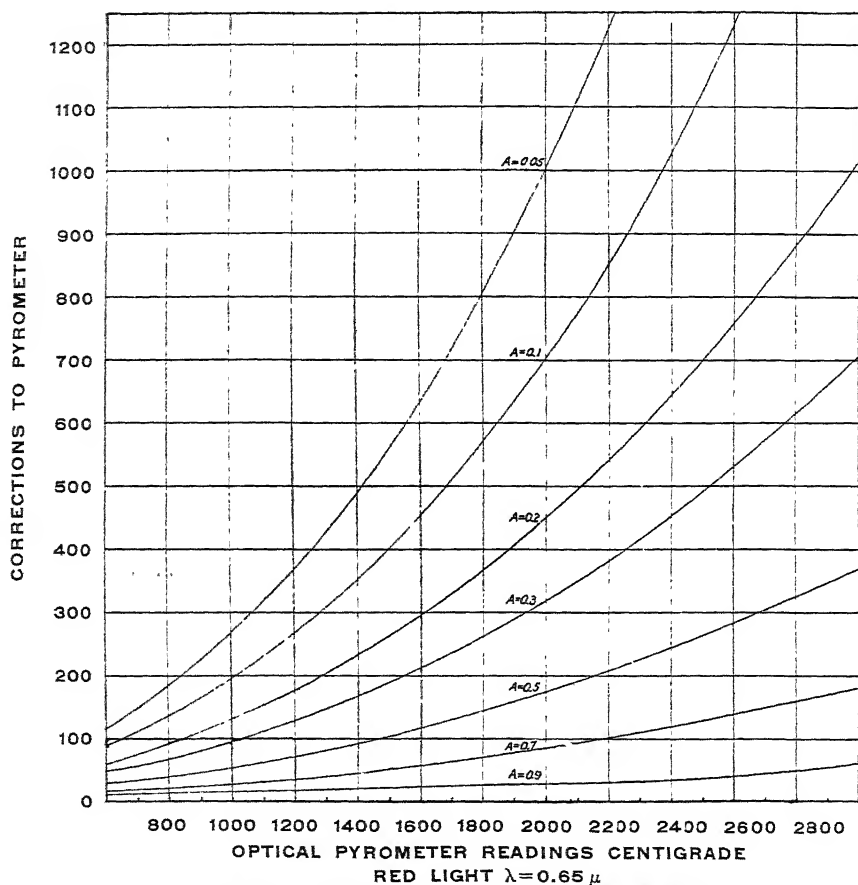


Figure 1. Graphic solution of Wien's spectral equation.

measurements,[1] and may be treated graphically by plotting $I_1 / I_2$ against $T$ for the wave lengths used.

[1] Thürmel, Ann. der Phys., **33**: 1139–1160. 1910. Wilsing and Schemer, Pub. Astrophys. Obs. Potslam, No. 56, 19.

A graphic solution of (2) suggested by v. Wartenberg[2] is to plot the curves $S$ = constant with values of $A$ as ordinates and of $T$–$S$ as abscissae.

In view of the fact that for any given substance the value of $A_\lambda$, in general, remains constant, it seems to us most convenient for the estimation of temperatures, of the several possible graphic methods, to plot the curves, $A_\lambda$ = constant, with the values of the pyrometer reading $S_\lambda - 273$ as abscissae and the correction $T - S$ as ordinates or its equal: $t - (S_\lambda - 273)$, where $t$ is temperature centigrade. Such a plot is shown in figure 1 for a pyrometer using red light of $\lambda = 0.65\mu$ and for the value $c = 14500$.

The same plot serves also for equation (1) for passing from one known temperature to another, unknown, when sighting on a black body. In this case the ratio $I_1 / I_2$ is usually given directly from a known relation of scale reading to intensity for the pyrometer used. When a considerable number of observations is to be taken, it is worth while to construct such a plot for the wavelength used.

Pirani[3] uses a protractor method for the solution of (2) by means of which a straight edge laid across the paper gives the value of $T$ by intersecting the values of $S$ and $A$.

Pirani also, but it would appear incorrectly, gives a similar graphical method for passing from the value of $A_{\lambda 1}$ to $A_{\lambda 2}$, or from the absorption coefficient as measured in terms of one wave length to that of another. He appears to assume that

$$\frac{\lambda_1}{c} ln\, A_{\lambda_1} \qquad \text{is equal to} \qquad \frac{\lambda_2}{c} ln\, A_{\lambda_2}$$

which is true, however, only in special cases (i.e., when $S_{\lambda 1} = S_{\lambda 2}$), as for instance the limiting case in which $T = S_\lambda$ (equation 2), or for a black body, and is therefore of no interest in the general case for substances possessing values of $A$ differing from unity,

[2] Über optische Temperaturmessungen blanker Körper. Verh. Phys. Ges., 12: 121–127. 1910.

[3] Über zwei Rechentafeln zum Gebrauch bei optischpyrometrischen Messungen. Verh. Phys. Ges., 12: 1054–1058. 1910.

since $S_\lambda$ and therefore $\dfrac{1}{T} - \dfrac{1}{S_\lambda}$ is a variable, depending on the specific emissive properties of the substance.[4] Applied for example, to the computation of the absorption coefficient of liquid copper[5] for green light, assuming that the value of $A$ for red is 0.15, Pirani's method gives an absurd result, i.e., 0.06 instead of 0.35 for $A_{.55}$.

It would lessen indefinitely the number of necessary observations if, in the general case, it were possible to compute the absorption coefficient for any wave length when that for one wave length is known. No such mathematical relation exists, however. Similarly, it is impossible either mathematically or graphically to find an exact, general relation between the true temperature of a substance and the apparent temperatures given by observations with light of two or more wave lengths except in terms of the absorption coefficients, $A_{\lambda_1}$ and $A_{\lambda_2}$, when equation (3) takes the form

$$ ln\,\frac{I_1}{I_2} = 5ln\frac{\lambda_2}{\lambda_1} + \frac{c}{T}\left(\frac{1}{\lambda_2} - \frac{1}{\lambda_1}\right) + ln\frac{A_{\lambda_1}}{A_{\lambda_2}} $$

in which the observed ratio $I_1/I_2$ is corrected for the sensibility of the eye. This equation may be solved graphically, among other ways, by plotting lines of $A_{\lambda_1}/A^{\lambda}_2 = $ constant with values of $I_1/I_2$ or its logarithm as abscissae and of $T$ or $t$, or their reciprocals as ordinates. There are, however, in certain cases, some of the metals for instance, convenient, simple empirical approximations connecting apparent temperatures with true, which may be expressed graphically.[6] Although it is impossible graphically or otherwise, to pass from one value $A_{\lambda_1}$ to another $A_{\lambda_2}$ unless the energy curve of the substance is known for these regions, yet it is possible to use equation (2) for the comparison of results of observers who have used different values of $c$.

[4] Holborn and Henning, Sitzber. Berlin Akad., 12: 311. 1905. G. K. Burgess, Bull. Bur. Standards, 1: 443–447. 1905.

[5] G. K. Burgess, Bull. Bur. Standards, 6: 111–119. 1909.

[6] Waidner and Burgess, Bull. Soc. Franç. de Phys., 200–204. 1907. Jour. de Phys., October, 1907.

In this case we may write, with Pirani,

$$a \log A = \log A' \dots \dots \dots \dots (4)$$

where $a = c \ c'$. since $c$, unlike $S$ or $A$, is independent of all the other quantities in equation (2). Equation (4) can be plotted in several ways, and permits a ready comparison of the otherwise somewhat contradictory results on the absorption coefficient of the same substance.

MINERALOGY.—*The chemical composition of nephelite.* WALDE-
MAR T. SCHALLER, Geological Survey.

The chemical composition of nephelite has long been a much discussed problem among mineralogists. One general theory endeavors to harmonize the analytical figures with the calculated values by the assumption of a number of complex formulas. The very complexity of these formulas is sufficient to cast doubts on their correctness. Another view is that the groups ($SiO_4$) and ($Si_3O_8$) can replace each other, in an isomorphous sense, so that by the presence of sufficient ($Si_3O_8$) replacing ($SiO_4$), the analytical figures obtained can readily be accounted for. Foote and Bradley have recently proposed[1] still another explanation, namely that as a substance on crystallizing may form a "solid homogeneous solution with foreign matter . . . ", the mineral nephelite consists of a pure compound, probably $NaAlSiO_4$, with a varying amount of dissolved silica. Such an interpretation certainly is suggestive but before it can be accepted for the case of nephelite it must be proved that the compound $NaAlSiO_4$ can dissolve silica. Furthermore, the fact that chemically the "dissolved silica" acts in an entirely different way from any known modification of silica must be satisfactorily accounted for.

I believe that the composition of nephelite can be readily explained without assuming complex formulas and without calling on the hypothesis of "dissolved silica." The mineral albite has the formula $AlNaSi_3O_8$ and the corresponding isomorphous mineral anorthite has the formula $AlCa_{\frac{1}{2}}SiO_4$. The soda anorthite,

[1] Foote, H. W., and Bradley, W. M.: On solid solution in minerals with special reference to nephelite. Amer. Jour. Sci., 4th ser., **31**: 25. 1911.

AlNaSiO$_4$, has been prepared artificially, and Washington and Wright have assumed[2] its presence to the extent of 5.58 per cent in a feldspar (anemousite) consisting essentially of albite and anorthite in isomorphous mixture.

We have, in the feldspars just named, two types of compounds, AlR'SiO$_4$ and AlR'Si$_3$O$_8$, and their isomorphous relation, as earlier developed by Clarke (Bull. 125, U. S. Geol. Survey) lead to a simple interpretation of the composition of nephelite. These compounds occur in several modifications, which are isomorphous. This relation can be best shown schematically.

MODIFICATIONS OF COMPOUNDS AlR'SiO$_4$ AND AlR'Si$_3$O$_8$

| COMPOUND | HEXAGONAL | MONOCLINIC | TRICLINIC |
| --- | --- | --- | --- |
| AlNaSiO$_4$ . . . | Essential component of nephelite; artificially prepared | | Artificially prepared; naturally only in mixture (carnegieite) |
| AlKSiO$_4$ ... | Kaliophilite | | |
| AlCa$_{\frac{1}{2}}$SiO$_4$. | Present in small amounts in the calcic varieties of nephelite | Celsian is the corresponding barium salt | Anorthite |
| AlNaSi$_3$O$_8$.. | Naturally only in mixture in nephelite | Barbierite | Albite |
| AlKSi$_3$O$_8$ ..... | | Orthoclase | Microcline |
| AlCa$_{\frac{1}{2}}$Si$_3$O$_8$ .. | | | |

The mineral nephelite is then an isomorphous mixture of the compounds crystallizing in the hexagonal modification, which are:

> AlNaSiO$_4$—essential component
> AlKSiO$_4$—kaliophilite
> AlNaSi$_3$O$_8$—best known in its triclinic form as albite.

To show that the explanation offered is in agreement with the analyses of nephelite it will suffice to quote two analyses, the first

[2] Washington, H. S., and Wright, F. E.: A feldspar from Linosa and the existence of soda anorthite (Carnegieite). Amer. Jour. Sci., **29**: 52. 1910.

one by Foote and Bradley and the second one by Morozewicz
(No. V—reference given in paper of Foote and Bradley). These
have been chosen as they are among the best analyses and show
a minimum amount of other bases such as CaO, $Fe_2O_3$, etc.

The nephelite analyzed by Foote and Bradley consists, as cal-
culated from their ratios, of the following compounds in the pro-
portions indicated.

*Compositi ·n of nephelite (Foote and Bradley)*
60 parts or 19.0 per cent of $KAlSiO_4$
245 parts or 70.4 per cent of $NaAlSiO_4$
21 parts or 10.6 per cent of $NaAlSi_3O_8$.

The comparison of the analysis with the figures calculated from
the above composition is very close, as is shown below.

COMPARISON OF ANALYSIS WITH CALCULATED VALUES

|  | ANALYSIS | CALCULATED |
|---|---|---|
| $SiO_2$ | 44 46 | 44 45 |
| $Al_2O_3$ | 33 11 | 33 37 |
| $Fe_2O_3$ | 0 96 | |
| $K_2O$ | 5.61 | 5.66 |
| $Na_2O$ | 16 32 | 16.52 |
| $H_2O$ | 0 38 | |
|  | 100.84 | 100 00 |

Analyses No. V of Morozewicz yields the following composition:

*Composition of nephelite (No. V Morozewicz)*
62 parts or 19 7 per cent of $KAlSiO_4$
259 parts or 74.7 per cent of $NaAlSiO_4$
11 parts or  5.6 per cent of $NaAlSi_3O_8$.

As in the other case, the comparison of the analysis with the
values calculated from the above composition, shows a very close
agreement.

COMPARISON OF ANALYSIS WITH CALCULATED VALUES

|  | | ANALYSIS | CALCULATED |
|---|---|---|---|
| $SiO_2$ | . | 42 71 | 43.04 |
| $TiO_2$ | . | 0 04 | |
| $Al_2O_3$ | | 33 83 | 34 20 |
| $Fe_2O_3$ | . . . | 0 40 | |
| $K_2O$ | . | 5 86 | 5 89 |
| $CaO$ | . . . | 0 32 | 16 87 |
| $Na_2O$ | . | 16 46 | |
| $H_2O$ | . | 0 18 | |
| Imp. | . . . . | 0 06 | |
| | | 99 86 | 100.00 |

The figures prove, I believe, that the composition of the mineral nephelite can be solved by the explanation herein offered which rests primarily on the isomorphous relation of $(SiO_4)$ and $(Si_3O_8)$.

The remarkable fact that the compound $KAlSiO_4$ is always present in nephelite to the extent of about 20 per cent has as yet not received any adequate explanation.

MINERALOGY.—*The alunite—beudantite group.* WALDEMAR T. SCHALLER, Geological Survey. To appear in the American Journal of Science.

A consideration of the various possible members of the alunite—beudantite group has led to some interesting results for fuller description of which reference must be made to the complete paper. Hamlinite is doubtless identical with goyazite; utahite, cyprusite, raimondite, pastreite, carphosiderite and apatelite are probably all the same mineral with the formula $H_2O.3Fe_2O_3.4SO_3.6H_2O$; and the probable compositions of pharmacosiderite and harttite are suggested. All of the minerals of these groups have very similar crystallographical and optical properties. Their formulas may be so written as to clearly bring out their close chemical relationship. The minerals may be placed into three sub-groups which are: sulphates, phosphates, and sulphate-phosphates respectively; the general formula for each of these sub-

groups being as follows:   Sulphates$[R''' (OH)_2]_6 . R''.[SO_4]_2.$  $[SO_4]_2,$
Phosphates.  $[R''' (OH)_2]_6 . R''.$  $[HPO_4]_2.$  $[R''(PO_4)_2]$ and Phos-
phate-sulphates  $[R'''(OH)_2]_6 . R''.$  $[SO_4]_2 . [R''(PO_4)_2].$   In the sul-
phate sub-group, $R'_2$ replaces $R''$ in most cases or else two uni-
valent alkali metals, such as $(K_2)$ may be considered equivalent
to $R''$.   Of the acid radicles the bivalent group $= [SO_4]_2$ is consid-
ered as isomorphous with the bivalent group $= [HPO_4]$.

MINERALOGY.—*The relations of purpurite and heterosite.*
   WALDEMAR T. SCHALLER.   To appear in Bulletin 490, U.
   S. Geological Survey.

The mineral purpurite, a hydrous manganic ferric phosphate,
$(Mn, Fe)_2O_3.P_2O_5.H_2O$, was first found in North Carolina, by
L. C. Graton, and a description of it was published[1] in 1905.

Since the original discovery the same mineral has been found at
other localities[2] (South Dakota, Connecticut).   Lacroix,[3] to whom
some of the original purpurite from North Carolina was sent, has
stated that purpurite is identical with heterosite.   In view of this
I propose that the name heterosite be restricted to the ferric
phosphate and the name purpurite to the manganic phosphate.
Heterosite predominates (76 per cent) in the material from South
Dakota while purpurite predominates (65 per cent) in that from
North Carolina.   More accurately the North Carolina material
should be called iron (or ferric) purpurite and that from South
Dakota and from France, manganese (or manganic) heterosite.

In the original paper describing purpurite the suggestion was
made that the pure end members could be called ferripurpurite
and manganipurpurite.   Since, however, the identity of the min-
eral with the French heterosite has been advocated by Lacroix,
the names ferripurpurite and manganipurpurite should be replaced
by the older names heterosite and purpurite respectively.

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[1] Graton, L. C., and Schaller, W. T.:  Purpurite, a new mineral.  Am. Jour.
Sci., 4th ser., 20: 146.  1905.
   [2] Schaller, W.T.:  Mineralogical Notes,—1. Purpurite from two new localities.
Am. Jour. Sci., 24:  152.  1907.
   [3] Lacroix, A.:  Minéralogie de la France, 4: 469.  1910.

MINERALOGY.—*Note on barbierite, monoclinic soda feldspar.*
WALDEMAR T. SCHALLER   To appear in a bulletin, "Mineralogical notes, Series II " of the U. S. Geological Survey.

In a recent paper[1] I proposed the name barbierite for the monoclinic soda feldspar isomorphous with orthoclase. A feldspar from Kragerö, Norway, analyzed by Barbier and Prost[2] is nearly pure barbierite, as only 1:15 per cent $K_2O$ was found.

Professor Barbier was kind enough to send me some slides of the feldspar from Kragerö which, according to his analysis, consists essentially of the soda compound. One of the slides, a basal section giving parallel extinction and appearing uniform, was uncovered and the feldspar washed free from Canada balsam. The mineral was then immersed in an oil with refractive index of 1.530 and it was seen that the index of the mineral was considerably lower than that of the oil. If the orientation of the mineral is the same as that of orthoclase then a basal section would yield values for $\alpha$ and for $\gamma$. As these were both found to be decidedly lower than 1.530, the section cannot be albite[3]. Unfortunately the very small section was accidentally lost before its soda content could be verified microchemically. The existence of a monoclinic form of the compound $Al_2O_3.Na_2O.6SiO_2$, different from albite, is therefore established.

PETROLOGY.—*Note on some albitite dikes in Nevada.* FREDERICK LESLIE RANSOME, Geological Survey.

The dikes here described occur in the southeast corner of Humboldt County, about thirty miles east-southeast of Lovelock, in that part of the Pahute Range that is locally known as the Stillwater, Silver, or Table Mountain, Range. They are associated with the nickel deposits of Cottonwood Canyon[1] and are intrusive as rather short irregular bodies into andesite and diorite.

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[1] Amer. Jour. Sci., 4th ser., **30:** 358. 1910.

[2] Bull. Soc. Chim., III, p. 894. 1908.

[3] For albite, $\alpha=1.529$, $\gamma=1.539$.

[1] Ransome, F. L.: Notes on some mining districts in Humboldt County, Nevada. Bull. U. S. Geol. Survey No. 414, pp. 55–58. 1909.

The rock is of almost snowy whiteness and consists chiefly of striated feldspar with minute, dark, disseminated crystals whose form and luster as seen under a hand lens are at once suggestive of anatase or rutile. The general texture of the rock is equigranular, the average diameter of the grains being 5 mm. or less.

In thin section under the microscope the rock appears as essentially an aggregate of subhedral and much-twinned plagioclase. Some of the angular spaces between the feldspar are filled with clear calcite, others with a fine-grained, foliated aggregate consisting chiefly of kaolinite, and still others with quartz.

The feldspar, which is generally fresh, has a refractive index of about 1.54, a birefringence equal to or lower than the quartz in the same section, an extinction angle on (001) of about 4° and an observed maximum extinction in the zone normal to (010) of 19°. It thus belongs at the albite end of the plagioclase series although it contains a small proportion of the anorthite molecule. The twinning lamellæ according to the albite and pericline laws, are generally thin, irregular and discontinuous, so that some of the crystals as seen in thin section have almost the plaid-like appearance of microcline. Carlsbad twins are rare and the crystals are not noticeably zoned.

The calcite areas as seen under the microscope are bounded in part by the crystallographic outlines of the albite and in part penetrate the contiguous fresh feldspar in a manner indicative of replacement. Without much doubt the calcite is secondary although it does not appear to have been formed by the local decomposition of feldspar but rather to have been introduced by solutions into miarolitic cavities which to some extent have been enlarged by metasomatism. The similarly interstitial kaolinite likewise shows no evidence of being a product of decomposition *in situ* and the adjacent feldspar is not kaolinized. The kaolinite also may have been carried into small cavities by infiltration. Finally, the quartz, which is not a conspicuous constituent and is not distinguishable at a glance from such sections of albite as show no twinning, may in part be of secondary introduction; for some of it displays the shadowy extinction and the suggestion of plumose structure that are specially characteristic of quartz deposited in veins.

The mineral noted as occurring in small glittering specks does not give any clear indication of its crystal form in thin section; but particles obtained by crushing the rock and concentrating the powder by panning, when examined under the microscope, show that the mineral has at least one perfect cleavage, that its luster is metallic-adamantine and that it crystallizes for the most part in acute, distorted, tetragonal pyramids, apparently the unit form, with strong transverse striations. A few, more regular forms were also observed in which the striations are limited to the equatorial zone of the crystal. The color by transmitted light is yellow to chestnut brown, with notable absorption in directions transverse to the prism axis. The index of refraction is high and the birefringence strong. Particles tested chemically by Mr. W. T. Schaller gave a strong reaction for titanium, which, with such crystallographic and optical data as have been recorded leaves little doubt of the identity of the mineral as anatase    The crystals, none of which is over a millimeter in length, occur embedded in all of the other constituents of the rock save apatite and zircon, which are the other accessory minerals present    With the apatite, moreover, it appears to have projected into the cavities now occupied by calcite.

Anatase is not a common rock constituent, and, where present, has generally been considered as a product of alteration. In these dikes, however, the mineral is apparently original for altho many of the crystals are enclosed in calcite others are embedded in fresh albite and in quartz.

A chemical analysis of a specimen of rock from one of the dikes near the nickel mine in Cottonwood Canyon is as follows:

*Chemical analysis of albitite*

George Steiger, analyst

| | | | |
|---|---|---|---|
| $SiO_2$ | 61 71 | $H_2O-$ | 0.51 |
| $Al_2O_3$ | 16.63 | $H_2O+$ | 0 81 |
| $Fe_2O_3$ | 0 40 | $TiO_2$ | 0 79 |
| $FeO$ | | $ZrO_2$ | 0 04 |
| $MgO$ | none | $CaO_2$ | 4 05 |
| $CaO$ | 5.94 | $P_2O_5$ | 0 15 |
| $Na_2O$ | 8.52 | | |
| $K_2O$ | 0.16 | | 99.71 |

The mineralogical composition as calculated from this analysis in accord with the microscopical examination, the small quantity of potash being included in the albite, is as follows:

| | |
|---|---|
| Albite (approx. Ab$_{96}$ An$_1$) | 76 5 |
| Calcite | 9 2 |
| Quartz | 8 8 |
| Kaolinite | 3 5 |
| Anatase | 0 8 |
| Apatite | 0 4 |
| Water | 0 8 |
| | 100 0 |

The calculation of the norm in order to find the place of the rock in the American quantitative system presents some difficulties, owing to the presence of the calcite. If the calcite were calculated as such it would place the rock with beerbachose in the dosalane class, where it evidently does not belong. If the carbon dioxide be disregarded and the analysis recalculated to 100, the derived norm shows an excess of calcium in the form of over 9 per cent of calcium metasilicate. In other words there is not enough alumina to combine with all of the alkalies and lime as feldspar. The norm on this basis falls in the unnamed persodic subrang of the alkalicalcic rang of the canadare order of the persalane class. On the other hand if both the carbon dioxide and the calcium oxide be rejected, the analysis recalculated to 100, and the norm then computed, the rock falls into the subrang tuolumnose in company with the somewhat similar soda-syenite porphyry of Tuolumne County, California, described by Turner[2] and the soda syenite or albite diorite[3] of Douglas Island, Alaska. This appears to be its natural association and the tentative calculation of the three norms, by showing that the lime is in excess of the quantity that can be combined with the available alumina to form feldspar, indicates either that the calcite is an original mineral (which the microscope disproves) or that the calcite has been

[2] Turner, H. W.. Further contributions to the geology of the Sierra Nevada, 17th Ann. Rept. U. S. Geol. Survey, Part I, p. 665. 1896.

[3] Spencer, A. C.: The Juneau gold belt, Alaska. Bull. U. S. Geol. Survey No. 287, pp. 99–105. 1906.

introduced into the rock and is not an ordinary decomposition product.

The known representatives of the subrang tuolumnose are not numerous, there being only three listed in Washington's tables [4] of which one, the albite diorite of Douglas Island, is considerably altered. This fact and the presence of anatase in the Nevada rock are thought to warrant the publication of this brief petrographic note.

BOTANY —*The genus Annona: the derivation of its name and its taxonomic subdivisions.* W. E. SAFFORD, Bureau of Plant Industry.

The genus Annona, which includes the custard apple (*Annona reticulata*) and the soursop (*Annona muricata*), was described by Plumier (1703) under the name of Guanabanus, which he adopted from *guanabano*, the vernacular name of one of the species on the island of Santo Domingo, published by Oviedo in his account of the fruit trees of the New World (1535).

Linnæus was at first inclined to accept as the name of this genus *Anona*, from the vernacular name *anon*, or *hanon*, applied to another species, and used by various early authors; but in his *Hortus Cliffortianus* (1737) he rejects both *Guanabanus* and *Anona*, as barbarous words, and substitutes for them the classic Latin *Annona*. This name, signifying "the year's harvest" of fruit, wine, etc., he thought particularly applicable, on account of the edible fruit of the Annona, which is relished by the natives of the countries where it grows.[1] This was in accordance with the principal of rejecting barbarous names, which he afterwards defended in his *Philosophie Botanique* (1788)[2].

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[4] Washington, H. S.: Chemical analyses of igneous rocks. Profess. Paper, U. S. Geol. Survey No. 14, p. 199. 1903.

[1] "Guanabanus et Anona sunt vocabula barbara, ut tamen servetur sonus Annonam dico ob fructum incolis gratum."—Linnæus, Hort. Cliff. 222. 1737.

[2] "Nous adoptons *comme nouveaux nés* des noms Barbares, auxquels nous avions donné l'exclusion, lorsque nous rendons nouveaux des noms à exclure, en les formant du Grec ou du Latin . . . . *Corossol*, Annona (Anona des Américains), de la moisson."—Linnæus, Phil. Bot. 208. 1788.

*Annona* then, and not *Anona*, must be the name used for the genus. It was published in the first edition of the Species Plantarum (1753), from which modern binomial nomenclature takes its origin; and it is equivalent to Plumier's genus *Guanabanus*, as stated by Linnæus in his Genera Plantarum (1754). He changes the name to Annona, and typifies the genus by the species *Annona muricata*, Plumier's "Guanabanus fructu e viride lutescente molliter aculeato."[3]

The name of the family must also preserve its original form *Annonaceae*, as published by Richard in 1808; not "Anonaceae," as published by Dunal in 1817, and by DeCandolle in 1818.[4]

The genus is naturally divided into several sections owing to the diversity in the form of the flowers. The subdivisions generally accepted heretofore have been: *Guanabani* (Plumier), including *Annona muricata* and its allies; *Attæ* (Martius), including *Annona squamosa* and its allies; and *Anonellæ* (Baillon), based upon *Annona globiflora*, a dwarf shrubby plant of eastern Mexico.

The discovery of new species with characters quite distinct from any of those included in the above sections has made an additional subdivision necessary, based upon *Annona macroprophyllata* the most striking peculiarity of which is the presence of broad persistent leaf-like bracts at the base of the peduncle. In conforming with modern botanical usage the author proposes the following names for the subdivisions of the genus.

SECTION I. **Euannona** (Type, *Annona muricata*).—In this section the flowers have a corolla composed of 6 broadly ovate or orbicular concave petals in two series, the 3 outer ones thick and leathery and more or less cordate at the base, the 3 inner ones somewhat smaller and thinner but conspicuous. Here are placed *Annona muricata*, the soursop, which is the type of the genus Annona; *Annona montana*, the wild soursop of the West Indies; *Annona glabra*, the alligator apple of mangrove swamps; *Annona purpurea*, the soncoya of southern Mexico and Central America; and *Annona uncinata*, an undescribed species from the *tierra caliente* of Mexico.

[3] Linnæus Sp. Pl. 536. 1753.—Gen. Pl. 241. 1754.
[4] Richard, Demonstr. Bot. ou Analyse du Fruit, 17. 1808.

SECTION II. **Atta** (Type *Annona squamosa*).—In this section the corolla is composed of 3 narrow, oblong or lanceolate petals, never opening to the base, or if there are 6 petals the inner ones are reduced to small scales. The peduncles are usually nodding or reflexed and are devoid of leaf-like bracts. Here are placed *Annona cherimolia* and the closely allied *Annona longiflora*, both of which have velvety leaves and delicious fruit called chirimoya; *Annona squamosa*, the sugar apple, atta, or pomme cannelle; *Annona reticulata*, the common custard apple, or "bullock's heart;" and *Annona scleroderma*, a new custard apple from Guatemala.

SECTION III. **Ilama** (Type, *Annona macroprophyllata*).—In this section the peduncles are remarkable for a pair of orbicular or oval persistent leaf-like bracts at their base. The corolla is composed of 3 oblong or linear petals swollen at the base and opening widely when the flower is mature. Here are placed *Annona macroprophyllata* and the closely allied *Annona diversifolia*, a new species from Colima. The name *Ilama* proposed by the writer for this section is a vernacular name of Aztec origin applied to the fruit of the latter species at Colima.

SECTION IV. **Annonella** (Type, *Annona globiflora*).—In this section are included dwarf shrubby species, with very small 3-petaled flowers and small net-veined leaves resembling those of certain species of Rollinia rather than the typical feather-veined leaves of the genus Annona. Here are placed *Annona globiflora* of eastern Mexico, the peculiar appearance and habit of which suggests to Baillon the creation of a separate section of the genus to include it, and *Annona palmeri*, a closely allied new species from the *tierra caliente* of western Mexico. In both of these species the fruit is about the size of a small peach, with little pulp surrounding the comparatively large yellowish Rollinia-like seeds.

# ABSTRACTS

ELECTRICITY.—*Copper wire tables.* Circular Bureau of Standards No. 32. 1911.

This circular was prepared at the request of the Standards Committee of the American Institute of Electrical Engineers. In its preparation the Bureau has had the coöperation of that Committee and the tables have been adopted as official by the Institute.

The circular discusses the results of work recently completed at the Bureau on the temperature coefficient and the conductivity of copper, as well as previous standard values, and gives a history of wire gages, showing that the trend of practice is toward expressing diameter directly in decimal fractions of an inch.

There are fifteen tables including complete reference tables for standard annealed copper, American Wire Gage, both in English and in metric units; and similar abbreviated "working tables" There are also tables for bare concentric cables of standard annealed copper and for hard-drawn aluminum wire. The tables also include comparisons of wire gages, and tables of temperature reductions, with complete explanations.

Four appendixes give additional information—the first on the units used in the expression of resistivity; the second on the calculation of the "resistivity-temperature constant" and on the expression of the temperature coefficient; the third on the density of copper; and the fourth on the calculation of the resistance and mass per unit length of cables.

J. H. DELLINGER.

AGRICULTURAL PHYSICS.—*Studies in soil physics.* E. E. FREE. Plant World, 14: Nos. 2, 3, 5, 7 and 8. 1911.

These five articles present briefly and in a non-technical way the author's point of view toward certain of the more salient points of soil

physics. Conceptions useful to the plant physiologist or ecologist are especially emphasized. The titles and main conclusions of the individual papers are as follows: (1) *The physical condition of soils.*—The range of physical conditions possible to a soil is determined by its ultimate physical nature or character, that is by the nature, size, and number of the particles of which it is composed. The physical condition, within this fixed range, is controlled by the moisture content by virtue of the surface tension on the water films between the soil grains. (2) *Movements of soil water.*—The capillary actions in the soil are controlled by the forces of surface tension on the water films. Permeability is a matter of the size of the individual interspaces of the soil, not of their total amount. (3) *Soil water and the plant.*—A very important but much neglected factor in the movement of water from soil to plant and through the plant is the evaporating power of the air. (4) *Physical constants of the soil.*—A critical examination of the various measurements which have been proposed as characteristic soil constants shows that all are in some degree unsatisfactory. The mechanical analysis in particular, is much less adequate than is usually believed. It is probable that another and better constant can be developed out of the water equivalent and the critical moisture content. (5) *Soil temperatures.*—The main effect of the soil character upon its temperature is due to its water capacity. The wetter soil warms and cools more slowly.    E. E. F.

ANALYTIC CHEMISTRY.—*The determination of sugars in grain and cattlefoods.* A. HUGH BRYAN, A. GIVEN and M. N. STRAUGHN. Circular 71, Bureau of Chemistry.

The determination of sugars in vegetable materials, either fresh or dried, having large quantities of starch, gums, fiber, etc., presents many difficulties. Methods for such determinations are few and in most cases are not explicit.

Extraction with hot water dissolves the sugars but also gelatinizes the starch and therefore produces changes in the sugar content, while cold water extraction causes the enzymes if present to become active and hence to change the sugar content during extraction. To inhibit the enzyme action alkalies are often added and the extraction carried on in the cold. A comparison of a method based on this procedure and of a method of extraction using 50 per cent alcohol has been made and as a result it is shown that with some substances the two methods give concordant results but the alkaline water extraction method is

open to many chances of error, viz., acidity of sample, fineness of sample and time of digestion, changes in sugar content after neutralizing the alkalinity, etc. These are separately treated.

The method proposed for extraction with the least chances of error is: Boil 12 grams of the finely ground material in a 300 cc. flask with 150 cc. of 50 per cent alcohol neutral in reaction for one hour, using a reflux condenser. Complete the volume to 300 cc., after cooling, with 95 per cent alcohol. Transfer 200 cc. to a beaker with a pipette and evaporate on a steam bath to 20 or 30 cc. Transfer this to a 100 cc. flask with water, clarify with a solution of neutral lead acetate, make to volume and filter. Remove the excess of lead, which should be very small, with anhydrous sodium carbonate, filter and determine the reducing sugars in an aliquot portion by one of the usual methods. Invert another portion with acid or invertase for the determination of total sugars.

For accurate work the volume occupied by the original substance must be taken into account. An average for a number of determinations shows that 12 grams of such material occupy about 12 cc. and hence the factor of 0.97 must be applied to the results. It is not well to weigh the precipitated cuprous oxide as such as this is often contaminated with nitrogenous bodies and also mineral matter, but the copper should be determined in it by some such method as Low's. Results are best reported as "Reducing sugars calculated as invert sugar" or "Reducing sugars calculated as dextrose" and "Total sugars by acid inversion calculated as dextrose (or invert sugar, as the case may be)" or "Total sugars by invertase calculated as dextrose (or invert sugar, as the case may be)."

If sucrose is calculated, it should bear some such wording as "Sucrose calculated from increase of sugars by acid inversion" or "Sucrose calculated from increase of sugars by invertase inversion." A. H. B.

AGRICULTURAL CHEMISTRY.—*Translocation of plant food and elaboration of plant material in wheat seedlings.* J. A. LeClerc and J. F. Breazeale. Bulletin Bureau of Chemistry No. 138. 1911.

Wheat was sprinkled upon thin perforated discs of aluminum and placed in pans of water to sprout. Samples of 100 to 200 were withdrawn at regular intervals, the plumule and radicle separated from the rest of the seed and analyses made of both portions. In this way the movement of the organic and inorganic salts from the bran and endo-

sperm into the plantlet was determined. The most noticeable feature of this movement was the action of the potassium. When the seedling was only two days old and weighed only about 6 per cent as much as the whole seed, it had absorbed about 50 per cent of the potash of the original seed as compared with 25 per cent of the nitrogen and 17 per cent of the phosphoric acid. Practically all of the salts were found to be absorbed at the end of the seventeenth day. Evidently there is no exchange of fat from the bran and endosperm into the plantlet. The amount of sugar both in the plantlet and in the residual seed reaches a maximum at about the seventh day and decreases rapidly from that time until the seventeenth day when the experiments were discontinued. The pentosans increased steadily throughout this period.

The effect of an outside application of plant food was tried with little effect. The plants were grown in nutrient solutions containing single salts and salts in combination but no appreciable difference could be detected in the movement of the plant foods from the endosperm and bran into the embryo.                                                                 J. A. B.

AGRICULTURAL CHEMISTRY.—*Methoxyl in soil organic matter.* E. C. SHOREY and E. C. LATHROP. Journal of the American Chemical Society, **33**: 75–78. 1911.

Methoxyl was found (by the Zeisel method) in small amounts in all but 2 of 10 soils widely varying in type and in character of organic matter. Its quantity bore no constant relation to, and is perhaps an unimportant part of the total organic matter of, the soil. It is probably derived from the decay of vegetable matter and its variation in soils of the same type indicates some fundamental difference in the chemical, physical, or biological factors that decide in what way a complex organic compound shall break down or decay when added to a soil.      E. C. L.

AGRICULTURAL CHEMISTRY.—*Lawn soils.* OSWALD SCHREINER and J. S. SKINNER. Bulletin Bureau of Soils, No. 75. 1911.

In this bulletin is presented the character of soils in respect to their mineral and organic materials, as well as the kind and amounts of different sized soil particles which determine the suitability of soils for lawn-making. The texture of soils and the relation of surface soil to subsoil receive consideration and the difference is pointed out between land devoted to lawn culture and to a farm crop. The movement of soil moisture, its dependence on texture, and its importance to the main-

tenance of a good greensward are explained. The presence of harmful compounds in certain soils is considered, as is also the influence of trees on lawns.

The best methods of building up grounds artificially by the hauling in of suitable material, both for subsoil fillings and for surface layering, are fully described, a list of soil types adapted to grass growing being given for this purpose.

While the bulletin is mainly for the purpose of aiding in the improvement of large tracts, the individual owner of a small plot in town or city has also been kept in mind.　　　　　　　　　　　　　　J. S. S.

AGRICULTURAL CHEMISTRY.—*Soil organic matter as material for biochemical investigation.* OSWALD SCHREINER and EDMUND C. SHOREY. Journal of the Franklin Institute, 171: 295. 1911.

Attention is called to the complexity of the organic matter of soils and the fruitful field of research that it offers for biochemical investigation. The importance of the chemical character of the organic matter of the soil is considered under four heads: its effect on crops; its effect on the bacteria and fungi of the soil; its influence on the physical properties of the soil; and its relation chemically to the mineral ingredients of the soil. By the application of the biochemical methods there have been isolated in this research twenty definite organic compounds thus far from that portion of soil organic matter included in the term humus. A chart shows the classification of these compounds, as well as methods of separation. The compounds comprise paraffin hydrocarbons, acids alcohols, esters, carbohydrates, hexone bases, pyrimidine derivatives and purine bases.　　　　　　　　　　　　　　M. X. SULLIVAN.

AGRICULTURAL CHEMISTRY.—*Studies in soil oxidation.* O. SCHREINER, M. X. SULLIVAN, and F. R. REID. Bulletin Bureau of Soils, No. 73. 1910.

The fact that roots possess the power of reduction is shown by the precipitation of tellurium and selenium from sodium tellurite and selenite, respectively. The oxidative power of the roots is shown by means of organic compounds, which, on oxidation, yield dyes that either color the solution or are deposited on the root surface. These two opposite properties may occur separately or concurrently, depending upon the reaction of the medium. Oxidation within the soil itself is demonstrated by the same reagents as those showing oxidation by the roots. The

reagent most successfully used in the case of soil is aloin, a solution of which in water is changed from yellow to claret red by the oxidation. The depth of color can be measured and indicates the extent of the oxidation.

This oxidation appears to be mainly nonenzymotic, the result of interaction between inorganic constituents and certain types of organic matter. It may also be brought about by organic matter in a state of autoxidation and by inorganic oxygen carriers, such as manganese and iron. Both processes activate oxygen.

The oxidation in soils was increased by the addition of salts of manganese, iron, aluminum, calcium, and magnesium, especially in the presence of simple hydroxyacids, such as citric, tartaric, malic, glycolic, and their salts. The best oxidation was obtained by the addition of manganese, and the stimulating action of manganese used as a fertilizer is attributed to its oxidizing power; i.e., to its amelioration of soil conditions rather than its function as a plant nutrient. Fertilizer salts augment the oxidizing power of roots, and the fertilized soil has an increased oxidizing power after cropping. The fertilizer salts alone sometimes increase, sometimes decrease, the oxidative functions of the soil, thus showing that the fertilizer salts are effecting changes directly or indirectly in the soil constituents more particularly in the organic matter. Some types of organic matter inhibit oxidation but in the main the oxidative power is augmented by a plentiful supply of organic matter, the nature of which in the soil is the limiting factor of oxidation. Excessive oxidation is harmful to vegetation.

Oxidation in soil is parallel to oxidation in plants and animals. Soils oxidize substances in a manner analogous to an oxidase, and the increase noticed by the addition of certain hydroxyacids is closely paralleled by the recently discovered activating action of salts of tartaric and citric acids on the oxidative action of manganese acetate. This analogy between the oxidative power of a soil and the action of an oxidase is especially significant in that an oxidizing enzyme, laccase, of alfalfa, has been found to be more simple in composition than formerly supposed and to consist of neutral salts, mainly calcium, of glycolic, mesoxalic, malic, and citric, and probably glyoxylic acid. It is well known that the oxidase whatever may be their nature, play an important part in the proper functioning of plants, and that with changes in the oxidizing ability are associated changes in plant condition. Similarly, oxidative power of the soil is a symptom of soil condition.

Whatever decreases the oxidation in soils tends also to bring about

the conditions which decrease growth, and the factors which favor oxidation are the factors which favor soil productivity.

O. S., M. X. S., and F. R. R.

AGRICULTURAL CHEMISTRY.—*Enzymotic activities in soils.* Oswald Schreiner and M. X. Sullivan. Science, 33:339, 1911.

Within the bodies of micro-organisms in plant roots and plant debris, in worms and animalcules, enzymes of various kinds must exist. Evidence of various enzymotic activities, proteolytic, amylolytic, inverting, cytolytic, lipolytic, etc., may be seen in many soils. Starches, sugars, cellulose, fat, and protein are speedily changed or disappear, and in many cases especially of proteins, some of the products of digestion may be found in the soil. As yet no satisfactory means have been obtained of extracting enzymes from soil to any great extent, though in those recently cropped there is some slight evidence of the presence of enzyme-like substances in the glycerine extract of the soil.          M. X. S.

AGRICULTURAL CHEMISTRY.—*The chemical nature of soil organic matter.* Oswald Schreiner and Edmund C. Shorey. Bulletin Bureau of Soils, No. 74. 1910.

This bulletin discusses the chemical nature of the organic compounds in the soil, and methods are described by which a number of organic compounds have been isolated from soils. These compounds, 16 in number, are described, the manner in which they have been identified pointed out, the possible sources of the compounds suggested, and their relation to other compounds stated. They belong to eight classes of chemical compounds, some containing carbon and hydrogen only, some containing carbon, hydrogen, and oxygen, and some containing carbon, hydrogen, oxygen, and nitrogen. Paraffin hydrocarbons, acids, alcohol esters, carbohydrates, hexone bases, pyrimidine derivatives, and purine bases are represented. The list of isolated and identified compounds comprises: Hentriacontane, $C_{31}H_{64}$; monohydroxystearic acid, $C_{18}H_{36}O_3$; paraffinic acid, $C_{24}H_{48}O_2$; lignoceric acid, $C_{24}H_{48}O_2$; phytosterol, $C_{26}H_{44}O.H_2O$; pentosan, $C_5H_8O_4$; histidine, $C_6H_9O_2N_3$; arginine, $C_6H_{14}O_2N_4$; cytosine, $C_4H_5ON_3.H_2O$; xanthine, $C_5H_4O_2N_4$; hypoxanthine, $C_5H_4ON_4$; fatty glycerides and several resin acids and esters.

This work shows that the complexity of the organic matter of soils is not so great but that the chemical nature of all of the organic matter of soils can be determined by modern methods.          E. C. S.

AGRICULTURAL CHEMISTRY.—*The oxidative and catalytic powers of soils and subsoils.* M. X. SULLIVAN and F. R. REID. Science, 33: 339. 1911.

Surface soils have the power to oxidize easily oxidizable substances such as aloin, guaiac, pyrogallol, hydroquinone, etc. When ten grams of soil are shaken with 500 cc. of a 0.1 per cent water solution of aloin, the yellow color of the aloin is changed to cherry red. On allowing the soil to settle, the solution can be filtered and the depth of color determined in the colorimeter. Broadly speaking, the oxidative power of the soil is symptomatic of a good soil condition, since soils of good productivity have in general good oxidizing power, while soils of poor productivity have, as a rule, poor oxidizing power. Subsoils have little, if any, action on aloin, though occasionally the oxidizing power of the subsoil may be as great or greater than the corresponding surface soil. The catalytic power of the soil or its capacity for decomposing hydrogen peroxide with the liberation of free oxygen is roughly parallel to the oxidative power, in that soils known to be of good productivity have strong catalytic power, while poor soils have weak catalytic power. The oxidative and catalytic powers of the soil are analogous to these powers in plants and animals and are modified in much the same way. M. X. S.

BIOLOGICAL CHEMISTRY.—*Biological analogies in soil oxidation.* OSWALD SCHREINER and M. X. SULLIVAN. Proceedings of the American Society of Biological Chemists, 2: 11. 1911. Journal of Biological Chemistry, 9: XVII. 1911.

The soil is the seat of many biochemical activities that directly or indirectly affect fertility. Many of the processes in the soil are analogous to those occurring in plants and animals. Soils may show fatigue under a one-crop system and under unsanitary conditions may contain material which is retardative of plant growth. Many other compounds, some of which are known to be products of proteolytic digestion, occur in soils. The soil *per se* has oxidizing and catalyzing powers which in cropped soils are due partly to activities of plant roots, but in air-dried soils are due mainly to non-enzymotic soil constituents, inorganic and organic, working separately, conjointly or in reinforcing and activating combinations. The recently discovered activating action of salts or organic hydroxyacids and the discovery that alfalfa laccase is a mixture of salts of organic hydroxyacids have a close counterpart in soil oxidation studies.                    O. S. and M. X. S.

BIOLOGICAL CHEMISTRY.—*Symptoms shown by plants under the influence of different toxic compounds.* OSWALD SCHREINER. Proceedings of the American Society of Biological Chemists, **2**: 7. 1911. Journal of Biological Chemistry, **9**: XIII. 1911.

Observations made in connection with the effects of different organic substances in modifying the growth of wheat seedlings has shown that toxic substances have a specific effect on certain plant functions. For instance, cumarin-affected plants have characteristic stunted tips and broad, distorted leaves. Vanillin strongly inhibits root growth. Quinone causes a tall and slender growth, with thin, narrow leaves, in strong contrast to the cumarin-affected plants. These various effects of toxic compounds are overcome by entirely different fertilizer combinations, the cumarin effect by phosphates, the vanillin effect by nitrates, the quinone effects by potassium salts. The absorption of salts while the plants are under the influence of these toxic compounds is likewise different, thus showing that the effect of the poisons is deep-seated, influencing the entire metabolism of the plants. The changes brought about by etherization and the influence of certain gases in causing the so-called sleeping of carnations and other flowers belong to this class of phenomena.

Previous work with plants and toxic compounds has usually been made without the recognition that plants are affected in a markedly different manner by different poisons. The plant, however, like the animal, shows characteristic symptoms of specific poisons and there is a pharmacology of plants as well as of animals.

That organic substances can cause changes in plant characteristics leads to the suggestion that harmful organic substances in the soil or in the plant may be the cause of some now little understood plant diseases. M. X. SULLIVAN.

GEOLOGY.—*The movement of soil material by wind.* E. E. FREE. With a *Bibliography of eolian geology.* S. C. STUNTZ and E. E. FREE. Bulletin Bureau of Soils, No. 68. Pp. 272. 1911.

This bulletin reviews the geologic actions of the wind with especial reference to its share in the moving of soil materials and in the making and mixing of soils. The phenomena of sand dunes, dust storms, eolian deposits (loess, etc.), blown volcanic dust, etc., are summarized and excessive soil blowing is briefly discussed. The main conclusion is that the wind is of considerable importance as an agent of soil formation and change, in humid as well as in arid regions. The literature of eolian geology is critically summarized and the bibliography of over 2000 titles is believed to be fairly complete. S. C. S. and E. E. F.

GEOLOGY.—*The geology and mineral resources of the Nizina District, Alaska.* F. H. MOFFIT and S. R. CAPPS. Bulletin U. S. Geological Survey, No. 448. Pp. 108, with maps, sections, and views. 1911.

The Nizina district embraces an area of about 300 square miles in the Chitina River valley, on the southeast side of the Wrangell Mountains. The geologic section, from the base up, comprises (1) the Nikolai greenstone, not less than 4000 feet thick, made up of lava flows, (2) the Chitistone limestone, 3000 feet thick, (3) the McCarthy shale, at least 2500 feet thick, and (4) the Kennicott formation, consisting of over 7500 feet of conglomerate, shale, and thin limestone. The Chitistone limestone and the conformably overlying McCarthy shale are Upper Triassic. They rest conformably on the Nikolai greenstone, whose age is not definitely known. The Kennicott formation is Upper Jurassic or possibly Cretaceous and rests on the eroded edges of the three older formations. It is intruded by numerous quartz porphyry dikes, which are rare in the older rocks. These four formations are closely folded, but are not greatly metamorphosed. A large part of the shales, heretofore regarded as Upper Triassic, are shown to be Upper Jurassic.

The Nikolai greenstone is of economic importance as a source of copper. Small bodies of copper ore are widely distributed through it and several large bodies, notably that of the Kennicott-Bonanza mine, are situated in the limestone near its contact with the greenstone. The copper, dissolved by water circulating through the greenstone, was precipitated in shear zones and fracture planes. Chalcopyrite, bornite, and chalcocite are the most important copper minerals. The Bonanza ore body, a large mass of chalcocite, is believed to be a primary deposit.

The placer gold of Dan and Chititu creeks is derived from small quartz veins in the Jurassic shales. These veins are probably related in origin to the numerous porphyry intrusions. Reconcentration of the high bench gravels has produced important stream placers.

Certain trains of rock waste that resemble glaciers in form and in other respects are believed to owe their movement to interstitial ice.

F. H. M.

GEOLOGY.—*Geology and oil resources of the Coalinga district, California.* RALPH ARNOLD and ROBERT ANDERSON. With a report on the *Chemical and physical properties of the oils.* IRVING C. ALLEN. Bulletin of the U. S. Geological Survey No. 398. Pp. 354, with maps, sections and views. 1910. Reprinted 1911.

The Coalinga district is a region of arid hills and mountain ridges bordering the west side of the great interior valley of California. The his-

torical record begins with the Franciscan rocks, marine Jurassic forma-
tions, which, probably in late Jurassic time, were extensively intruded
by basic igneous rocks.   Since then they have repeatedly been exposed
to erosion and have furnished materials for some of the Tertiary strata.
The lower Cretaceous record is scant, the region having been a land area
during much of that period.   During the upper Cretaceous on the other
hand this region was covered far and wide by the sea and the great mass
of conglomerate, sandstone and shale then deposited is in places still
represented by a thickness of nearly 10,000 feet.   The Tertiary section
is especially complete, with a thickness of 13,000 feet of sedimentary strata
separable by unconformities into six or seven important formations
containing abundant fossils.   It shows that this region was land from the
beginning of the Tertiary until the commencement of estuarine deposi-
tion in the Tejon period.   Not long after this, in the late Eocene or Oli-
gocene, came the deposition of a great body of diatomaceous shales, of
which a thousand feet are still preserved beneath the important erosional
unconformity which separates them from the marine Vaqueros sandstone
of the lower Miocene.   After the lower Miocene there was again a land
interval, followed by submergence beneath the sea in the middle Miocene
Santa Margarita period, which in turn was brought to a close by uplift
and was succeeded at least locally by an interval of erosion.   During
the upper Miocene and perhaps also early Pliocene epochs fluctuating
littoral marine conditions prevailed, with the resultant deposition of
variable sediments that make up the Jacalitos and Etchegoin formations.
Part of the Pliocene and probably also the early Quaternary was taken
up by the deposition of several thousand feet of freshwater, fluviatile
and marine sands, gravels and clays composing the Tulare formation,
after which there came one of the principal epochs of orogenic movement
to which the Coast Ranges have been subjected, with the consequent
uplifting and folding of all the strata that precede in time the later
Quaternary valley fillings.

Among the more interesting facts brought out in the study of this
region are the following:   (1) the upper Cretaceous age of an organic
shale formation hitherto thought to be Eocene; (2) the presence of a
thick diatomaceous shale formation in the Eocene or Oligocene, and of
a similar formation in the middle Miocene—the one earlier and the other
later than the well known Monterey shale, with which both had been
correlated before; (3) the probable middle Miocene and pre-San Pablo
age of the Santa Margarita formation; (4) the Miocene age of the greater
part of the Etchegoin formation, hitherto regarded as Pliocene; (5) the
unconformities of the Eocene on the Cretaceous, of the Miocene on the

Oligocene or Eocene, and of various parts of the Miocene upon each other; (6) the occurrence of the principal orogenic movements of Cenozoic time in four different periods—at the beginning of the Eocene, in the late Eocene or Oligocene, in the early middle Miocene, and in the late Pliocene or early Quaternary.

The evidence as to the origin of the petroleum from minute marine organisms such as diatoms and foraminifera amounts almost to proof. There are two distinct oils in the Coalinga district, one a paraffin oil that comes from organic shale in the Cretaceous and another an asphalt oil almost certainly derived from the diatomaceous Eocene or Oligocene shale. The presence of oil in association with these shales wherever they are present, and its unfailing absence where they are lacking is the most striking of the facts leading to the conclusion that they were the original source of the oil. R. ANDERSON.

BOTANY.—*Experiments in blueberry culture.* FREDERICK V. COVILLE. Bulletin 193, Bureau of Plant Industry, Department of Agriculture. Pp. 100, pls. 18, figs. 31. 1910.

As a result of four years' experimentation with the swamp or high-bush blueberry (*Vaccinium corymbosum*), sometimes objectionably called huckleberry, it has been found that these plants thrive only in acid soils. They fail to grow satisfactorily in a rich garden soil of the ordinary type, in a soil made sweet by lime, in a thoroly decomposed leafmold such as has a neutral reaction, or in a nutrient solution with alkaline reaction. They require an acid nutrient solution or an acid medium of some sort, thriving especially in bog peat or in the acid leaf litter of sandy pine or oak woods.

This type of upland leaf deposit, in which decomposition is retarded for many years, is regarded as essentially peat and in distinction from bog peat is called upland peat. An upland peat is described as a non-paludose deposit of organic matter, chiefly leaves, in a condition of suspended and imperfect decomposition and still showing its original leaf structure, the suspension of decomposition being due to the development and maintenance of an acid condition which is inimical to the growth of the micro-organisms of decay. The use of the name "leaf-mold," sometimes applied to this upland peat, should be restricted to the advanced stages in the decomposition of leaves, in which leaf structure has disappeared. Typical leafmold is neutral or alkaline in reaction, a fundamentally important characteristic.

The rootlets of healthy plants of the swamp blueberry are inhabited

by a symbiotic fungus, of the sort known technically as an endotrophic mycorhiza. There is strong evidence that this fungus acts as a purveyor of nitrogen to the blueberry plant, a highly important function since the formation of nitrates in these soils through the agency of nitrifying bacteria is inhibited by the presence of organic acids.

The experiments appear to warrant the following theory of the method of nutrition of the swamp blueberry: (a) The swamp blueberry grows in peaty soils which contain acid or other substances poisonous to many plants. (b) As a protection against the absorption of amounts of these poisons great enough to prove fatal, this plant, like many other bog and acid-soil plants, is devoid of root hairs and consequently has a restricted capacity for absorbing soil moisture. This low absorptive capacity is correlated with a low rate of transpiration. Many bog shrubs, altho living with an abundant supply of moisture at their roots, have been recognized as showing adaptations for retarded transpiration similar to desert plants. (c) The special danger to which the swamp blueberry is exposed by reason of its low transpiration and its corresponding reduced capacity for absorption is insufficient nutrition. The danger of nitrogen starvation is particularly great since these soils contain very little nitrates. (d) Some bog plants similarly threatened with insufficient nutrition, such as the sundews (Drosera), the bladderworts (Utricularia), the pitcher plants (Sarracenia), and the Venus flytrap (Dionæa), possess means of securing the requisite nitrogen by catching insects and digesting and absorbing their nutritive parts. (e) In the swamp blueberry the required nitrogen is secured in a different way. The plant associates with itself a mycorhizal fungus which is able to assimilate nitrogen from the surrounding organic matter, and perhaps from the atmosphere also, and to convey it into the plant without taking along with it a large amount of the poisonous soil moisture.

Whether this theory of the nutrition of the swamp blueberry is or is not substantiated in all its details by future investigation, it has afforded a useful basis for cultural experimentation. A method of blueberry culture has been worked out under which these plants grow with unexpected luxuriance and there is every prospect that the result will be the establishment of a new agricultural industry, the commercial cultivation of the blueberry.                                        F. V. C.

FORESTRY.—*Properties and uses of Douglas Fir.*  McGARVEY CLINE
and J. B. KNAPP.   Forest Service Bulletin No. 88.   Pp. 75, with
plates and diagrams.   1911.

Douglas fir is perhaps the most important of American woods.   It is
manufactured in almost every form known to the sawmill operator and
much round and hewed timber is used.

Tests on 8 inch by 16 inch by 16 feet Douglas fir bridge stringers
gave an average fiber stress at elastic limit, for all grades, of 4000 pounds
per square inch when green, and 4467 pounds per square inch when air-
dry; a modulus of rupture of 6000 pounds per square inch when green,
and 6327 pounds per square inch when air-dry; and a modulus of elas-
ticity of 1,510,000 pounds per square inch when green, and 1,540,000
pounds per square inch when air-dry.   Tests on smaller pieces, free from
defects, to determine the properties of green material, gave an average
fiber stress at elastic limit of 5500 pounds per square inch; a modulus of
rupture of 8400 pounds per square inch; and a modulus of elasticity of
1600 pounds per square inch.   Compression parallel to the grain gave
a crushing strength at elastic limit of 3600 pounds per square inch.
Shearing tests gave an average result of 770 pounds per square inch.
Douglas fir varies greatly in quality, the different strength functions rang-
ing in value 50 per cent above and below the averages quoted.   Tests
show that the so-called red and yellow fir have practically the same
strength.   The mechanical strength of Douglas fir varies directly with
dry weight.   Pieces which exhibited the greatest strength show usually
a rate of growth beween 12 and 16 rings per radial inch.   The presence
of knots appreciably decreases the strength of green Douglas fir in
compression parallel to grain.   In beams, the presence of knots affects
most the modulus of rupture.   The tendency of specifications for Doug-
las fir is toward too great severity.                      FINDLEY BURNS.

AGRICULTURE.—*The theory and practice of soil management.*   FRANK
· K. CAMERON, Bureau of Soils.   An address before the Michigan
Academy of Science, at Lansing, Michigan, April 5, 1911.   To
appear in its Proceedings.

The soil possesses individuality, its problems are dynamic rather than
static, crop production is a complete function in which all the variables
are dependent, and various theoretical considerations which hitherto
have not received due attention indicate a greater producing power in
our soils than has yet been realized in practice.   That high production
is desirable in all cases is open to question and involves economic factors
that must be considered for particular cases.                F. K. C.

AGRICULTURE.—*The use of soils east of the Great Plains region.*
MILTON WHITNEY.  Bulletin Bureau of Soils, No. 78.  Pp. 292,
Pl. 1 (map), figs. 16.

This is a comprehensive bulletin, embodying the results of the soil
surveys from their inception to January 1, 1910.  All the soil types
established on or before that date are briefly described and their prin-
cipal uses stated.  The soils are grouped in provinces and in classes, the
latter based upon textural similarity, and the natural crop adaptations
predicated broadly on this basis.  The bulletin is divided into seven
principal sections, corresponding with the seven soil provinces, and
with each section is given a key to the classification of its soils, showing
diagrammatically the origin, processes of formation, and other salient
characteristics of the various soil series.  A map of the soil provinces
of the eastern half of the United States showing the exact location of the
soil survey areas so far completed accompanies the volume.    M. W.

CONCHOLOGY.—*The west American mollusks of the genus Eumeta*
PAUL BARTSCH.  Proceedings U. S. National Museum. **39**: 565–
568, figs. 1–3.  1911.

In this paper *Eumeta intercalaris* Carpenter, *bimarginata*, C. B. Adams,
and *eucosmia*, the last a new species, are described and figured.  P. B.

CONCHOLOGY.—*The recent and fossil mollusks of the genus Diastoma
from the west coast of America.*  PAUL BARTSCH.  Proceedings
U. S. National Museum, **39**: 581–584.  1911.

This paper is a monograph of the members of this genus occurring on
the west coast of America, all of the known species being described and
figured.  The following are new:  *Diastoma chrysalloidea, oldroydæ*
and *stearnsi.*                                                          P. B.

CONCHOLOGY.—*The recent and fossil mollusks of the genus Cerithi-
opsis from the west coast of America.*  PAUL BARTSCH.  Proceedings
U. S. National Museum, **40**: 327, pl. 36–41.  1911.

This is a monograph of the west American members of this genus,
containing descriptions of the new sub-genera *Cerithiopsina, Cerithiop-
sida and Cerithiopsidella.*  The following species are described as new:
*Cerithiopsis (Cerithiopsis) fatua, oxys, carpenteri, abreojosensis, berryi,
galapagensis, cesta, stejnegeri dina, halia, aurea, (Cerithiopsina) necro-
politana, adamsi, (Cerithiopsida) diegensis, rowelli, (Cerithiopsidella)*

*antefilosa, alcima; Cerithiopsis (subgenus?) curtata, fossilis, gloriosa, para-maea. bicolor. arnoldi, magellanica. antemuda, diomedeæ* and *monte-reyensis.*                                                                                   P. B.

ENGINEERING.—*Progress and present status of the good roads move-ment in the United States.* LOGAN WALLER PAGE, Director, Office of Public Roads.   Yearbook of the Department of Agriculture, 1910.  1911.

The subject is discussed under the following titles: "Period of Colonial Existence," "Early National Existence," "From 1860 to 1890," "State Aid," "Present Trend." The author tells of the early need for roads as a means of communication between the various colonial settlements and for the transportation of troops, arms and ammunition in the numerous colonial conflicts. The work was largely accomplished by levying labor taxes, and for two centuries nothing more was attempted than to meet the most pressing exigencies. With the American Revolution, and the following increase and spread of population and development of commerce, road building became of paramount importance. A decided movement for better roads was begun, which was manifested by the construction of toll roads by private capital. Strong sentiment for national roads also grew up, and numerous appropriations from the national treasury were made for the purpose, but national participation ended with the Civil War and the consequent heavy national debt. From this time on little attention was given to road improvement until the closing years of the last century.

The author then discusses the development of State aid sentiment in recent years, and the present trend toward more effective highway legislation and skilled supervision, as well as reforms in methods of construction and maintenance.                                        C. S. REEVE.

ENGINEERING.—*Bitumens and their essential constituents for road construction and maintenance.* PREVOST HUBBARD, Circular 93 of the Office of Public Roads, U. S. Department of Agriculture. 1911.

This publication presents in condensed form a description and discussion of various bituminous road materials, in an attempt to dispel the existing confusion concerning the meaning of certain terms applied to these materials. The definitions are still more or less arbitrary and the circular will therefore be revised from time to time in order to keep it abreast with the latest information obtainable.

Definitions and brief discussions occur under the following titles, which are arranged alphabetically:

Acid sludge, anthracene, artificial asphalt, artificial bitumens, asphalts, asphaltenes, asphaltic petroleums, asphaltic cement, Baumé gravity, benzol, bitumen, bituminous, blown petroleum, carbenes, carbon bisulphide, carbon tetrachloride, coal tar, coke-oven tar, cracked oil, cracking, cut-back products, dead oils, destructive distillation, dehydrated tar, emulsions, fixed carbon, flux, free carbon, gas-house coal tar, gilsonite, grahamite, high-carbon tars, hydrocarbons, low-carbon tars, malthas, malthenes, mineral rubber, naphthas, naphthalene, native bitumens, oil asphalts, oil pitches, oil tars, paraffin naphthas, paraffin petroleum, paraffin scale, paraffine, petrolenes, petroleums, petrolic ethers, pitches, pyrobitumens, pyrogenetic, reduced petroleums or reduced oils, refined tar, residual petroleums or residual oils, residual tars, rock asphalt or bituminous rock, semiasphaltic petroleums, short, tar pitches, tars, water-gas tars. C. S. REEVE.

ENGINEERING.—*Methods for the examination of bituminous road materials*. PREVOST HUBBARD and CHARLES S. REEVE. To be published as Bulletin No. 38 of the Office of Public Roads, U. S. Department of Agriculture.

This bulletin describes methods now in use by the Office of Public Roads for the examination of bituminous road materials. These are given in detail with illustrations of practically all of the necessary apparatus; so that any intelligent person may, with a little practice, and the proper equipments, make the desired tests.

For the purpose of examination, bituminous road materials are classified as follows: (1) Petroleums and petroleum products, including residual petroleums, fluxes, oil asphalts, and fluxed or cut-back oil asphalts. (2) Malthas. (3) Asphalts and other solid native bitumens, and asphaltic cements produced by fluxing same. (4) Tars and tar products. (5) Mixtures of tar with petroleum or asphalt products, bituminous emulsions, and factitious asphalts. (6) Bituminous aggregates, including rock asphalts or bituminous rocks, bituminous concrete and asphalt or other bituminous topping.

A scheme of examination for each of the above classes is then discussed with relation to the particular tests applicable to each class.

An appendix contains an itemized list of the necessary equipment for a small laboratory, metric conversion tables, degrees Baumé and specific gravity, and Centigrade and Fahrenheit degrees comparison tables, concluding with forms for reporting and recording tests. C. S. R.

# REFERENCES

AGRICULTURE.—*Soil Surveys* (Advance Sheets—Field operations of the Bureau of Soils, 1909) as follows:

*Gaston County, N. C* W. E. HEARN. L. L. BRINKLEY and F. P. DRANE. Pp. 33. Map.

*Washington County, N. Y.* M. E. CARR, G. A. CRABB, V. J. FROST and D. W. HALLOCK. Pp. 52. 2 Maps.

*Campbell County, Va.* R. A. WINSTON. Pp. 39. Map.

*Waushara County, Wis.* J. W. NELSON, G. CONREY. A. K KUHLMAN. Pp. 33. Map.

*Coffee County, Ala.* L. A. HURST and A. D. CAMERON. Pp. 51. Map.

*Scotland Co., N. C.* R. B. HARDISON, J. W. NELSON, and D. D LONG, Pp. 32. Map.

*Western South Dakota.* (Reconnaissance.) G. N. COFFEE. Pp. 80. Map.

*Woodland Area, Cal.* C. W. MANN, J. F. WARNER, H. L. WESTOVER. and J. E. FERGUSON. Pp. 57. 2 Maps.

*Clay County, Miss.* E. L. WORTHEN. Pp. 41. Map.

*Rice County, Minn.* R. T. A. BURKE and L. A. KOLBE. Pp. 39 Map

*Cedar County, Mo.* E. B. WATSON and H. F. WILLIAMS. Pp. 34. Map.

*Southwestern Pennsylvania.* (Reconnaissance ) H. J. WILDER and C. F. SHAW. Pp. 69. Map.

*Berks County, Pa.* W. J. GEIB, E. L. WORTHEN, F. S. WELSH, J. C. BRITTON and C. R. ZAPPONE, JR. Pp. 47. Map.

HYDROLOGY.—*Surface water supply of the United States, 1909:* Part VII. *Lower Mississippi Basin.* W. B. FREEMAN and R. H. BOLSTER. Water-Supply Paper, U. S. Geological Survey No. 267. Pp. 99, with views. 1911.

*Surface water supply of the United States, 1909:* Part VIII. *Western Gulf of Mexico.* W. B. FREEMAN and R. H. BOLSTER. Water-Supply Paper, U. S. Geological Survey No. 268. Pp. 107, with views. 1911.

*Quality of the water supplies of Kansas.* H. N. PARKER. With a preliminary report on *Stream pollution by mine waters in southeastern Kansas.* E. H. S. BAILEY. Water Supply Paper, U. S. Geological Survey No. 273. Pp. 375, with maps. 1911.

STATISTICS.—*Mineral resources of the United States, calendar year 1909.* Part I—*Metals.* Part II—*Nonmetals.* U. S. Geological Survey. 1911.

# PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

## THE GEOLOGICAL SOCIETY OF WASHINGTON

At the 243d meeting, at the Cosmos Club, April 12, 1911, the following paper was presented and illustrated by lantern slides:

*The physical conditions under which Paleozoic coral reefs were formed.* T. WAYLAND VAUGHAN.

As the physical conditions prevalent during the formation of fossil coral reefs cannot be ascertained by direct observation, it is necessary to resort to the process of deduction. Evidence for establishing criteria may be derived from two sources: The first, through the study of the conditions under which modern reefs are formed, and the determination of the factors necessary for the physiologic activity to which large accumulations of calcium carbonate are due; the second, through the investigation of the physical character and the nature of the bedding or stratification of the sediments in which the fossil reefs are embedded. The distribution of reef corals and other organisms that form calcareous reefs were considered with reference to depth of water and intensity of light, temperature, motion of the water, character of bottom, composition of the oceanic salts and the specific gravity of the water. Especial attention was paid to the diminishing strength of light with increase in depth of the sea as limiting the downward extension of reef-forming corals. In this connection attention was called to the fact that at the government wharf at Fort Jefferson, Tortugas, which is supported by iron piles coated with cement, there are many corals on all the peripheral piles while on those in the permanently shaded areas there are none.

The results obtained by Sir John Murray from studying the effects of temperature on the distribution of lime secreting organisms were cited as bearing on the problem under consideration. According to this investigator it appears "that the most favorable conditions are met with in the warm, equable, tropical waters of the ocean, and here as a matter of fact we find the greatest development of corals, and the largest number of lime secreting pelagic organisms. In the polar areas and in the cold water of the deep sea there is, as is well known, a feeble development of all carbonate of lime structures in marine organisms."

The data on conditions under which modern coral reefs are formed were summarized as follows: (a) *depth*, maximum, 25 fathoms; light, strong; (b) *temperature*, annual minimum 68° F., annual mean above 70° F.; (c) *water*, agitated and circulating; (d) *bottom*, firm or rocky, without silty deposits; (e) *composition of the oceanic salts*, as for the oceanic waters as a whole; (f) *specific gravity*, as for the ocean in general, range 1.02405 to 1.02748. Of these conditions shallow water, strong light, high temperature, circulating water, a comparatively clean sea-floor, and a chem-

ical composition of the water insuring a supply of calcium salts for the formation of the skeletons are essential.

The speaker then gave a brief review of both the stratigraphic and geographic distribution of Paleozoic coral reefs, calling attention to the more important constituent genera. The Paleozoic coral reefs begin in the lower Cambrian and extend through the Carboniferous. The same groups of reef-building organisms are represented in both the Paleozoic and Recent seas; in both they have the same facies as regards growth-form; in both, their physiologic activity has resulted in the secretion of large quantities of carbonate of lime from the surrounding sea-water; and in both, submarine banks, known as coral reefs, have resulted. The general similarity of the organisms and the similarity in the result of their physiologic activity, suggest similarity of conditions under which his activity took place.

The nature of the sediments and the character of the stratification of the beds in which occur the Silurian reefs of Gotland and Cedarburg, Wisconsin, and the Devonian reefs of Wisconsin and New York, were reviewed. As the materials of the matrix in which the reefs are embedded are largely fragmental, and as cross bedding and other evidence of shallow water deposition is furnished, the conclusion was reached that these Paleozoic reefs were formed in shallow, agitated, and presumably, therefore, well-lighted, waters.

The conditions under which Paleozoic reefs were formed were summarized as follows:

(a) *Depth*, maximum 25 fathoms; light, strong. (b) *Temperature*, annual minimum not lower than between 60 and 70° F., and probably above 70° F. (c) *Water*, agitated and circulating. (d) *Bottom*, clear or relatively free from deposits of silt. (e) *Composition of the oceanic salts*, probably the same as in the ocean of the present day. (f) *Specific gravity of the oceanic waters*, probably about as in the ocean of today. Certainly the specific gravity was high enough to furnish the large quantities of calcium salts demanded by the reef organisms for the formation of their skeletons.

Bonney says in his appendix to Darwin's *Structure and Distribution of Coral Reefs*, p. 331: "Moreover, the *aporosa* and *madreporaria*, which are now the chief reef-builders, have only become common since the conclusion of Paleozoic ages, so that the largest volume of the geological history of the earth is excluded from consideration, because in the time which it covers the habits of the reef-builders may have been different." The evidence presented by Dr. Vaughan showed in his opinion, that the habitats of reef-building corals have always been similar.

Sir John Murray discussed Dr. Vaughan's paper, paying especial attention to the conditions under which organisms secrete large quantities of calcium carbonate in the ocean. He gave a brief review of the distribution of the coral reefs of the globe, described the origin of coral reef foundations, and outlined the theories of the formation of the various types of coral islands.        E. S. BASTIN, *Secretary.*

The program of the 244th meeting, at the Cosmos Club, April 26, 1911, was as follows:

*Notes on the geology of the Koyukuk-Kobuk region, Alaska.* PHILIP S. SMITH.

There are two main physiographic features (1) a high mountain mass to the north known as the Endicott or Baird Mountains, which has been correlated with the Rocky Mountain system in the States, and (2) irregularly distributed highlands and lowlands to the south, forming what has been called the central plateau province. Roughly speaking, the mountain province lies to the north of the Kobuk, and the central plateau province to the south of that river.

The geology of the Endicott Mountains is complex. Schists, limestones, and intrusives, Paleozoic or older in age, are intruded by granular rocks, both granites and diorites, probably of Mesozoic age. Presumably these mountains owe their main outlines to post-Cretaceous deformation and it is possible that this period of mountain building may have occurred well along in the Tertiary. The mountains have been eroded by glacial as well as fluviatile agencies.

The southern province consists mainly of deformed Cretaceous and older metamorphosed sedimentary rocks, the oldest of which have been intruded by granular igneous rocks. In the lowlands Tertiary (?) lavas have been extruded on the eroded surfaces of the older rocks and here and there extensive deposits of gravel reaching to elevations of 500 to 600 feet above the main drainage lines probably represent deposits formed during the waning of glaciation in the mountain province.

One of the striking features of the region is the irregular arrangement of the drainage. Certain of the larger streams flow transverse to the ranges in rocky gorges. The valleys of these streams have been occupied by glaciers or were the spillways through which glacially impounded drainage was discharged.

A summary of the geologic history is as follows: The earliest recorded event was the laying down of the sedimentary rocks of the Endicott Mountains. These, after consolidation, were deformed and intruded by basic igneous rocks and then intensely folded so that the rocks became crystalline schists.

After deformation, the region appears to have remained above the sea until the laying down of the Mesozoic sediments. Into these rocks and probably into the metamorphic rocks, granitic and dioritic intrusives were injected probably in middle Jurassic time. These intrusions were followed by erosion and by the laying down of Cretaceous sediments. Subsequently these rocks were deformed although there was no accompanying development of schistosity. During this period the major outlines of the present topography were blocked out.

*A new system of Quaternary lakes in the central Mississippi Basin.* E. W. SHAW.

Many of the low-lying parts of the central Mississippi Basin are underlain by a more or less laminated clay containing locally, especially about

the borders, a little fine sand. This clay, by its character and physiographic expression indicates a great system of extinct lakes hitherto undescribed extending from southern Wisconsin to eastern Kentucky. The clay lies at concordant elevations and occupies an aggregate area of several thousand square miles. The physical character, horizontal attitude of the surface, shore features and fossils show that the material is in large part of lacustrine origin, and it appears that the lakes were formed through the rapid development of valley trains on the Mississippi and Ohio in late glacial time the outwash débris damming the lower ends of tributary valleys. The lake deposit is thus a "valley fill," and ranges in thickness up to 130 feet. In each valley the surface of the fill is practically horizontal but the altitude of the surface varies from valley to valley. The height increases regularly from Cairo up the Mississippi and from the same point up the Ohio. The height and hence the extent of the water in each lake being controlled by the river, fluctuated as the river rose and fell, but the lakes served as reservoirs so that the range between high and low water was not so great as it would otherwise have been. Shore features were generally poorly developed but in places, as near Madisonville, Kentucky, there are unmistakable beach ridges.

*Discussion of the Cretaceous and Tertiary floras of Alaska.* ARTHUR HOLLICK.

About 200 separate collections of fossil plants from Alaska were subjected to critical examination. The localities represented range from Herendeen Bay near the end of Alaska Peninsula, along the coast line to Prince of Wales Island, and through the interior down the Yukon Valley from Eagle to the vicinity of Kaltag, besides several scattered localities in the Tanana region.

Three and possibly four, more or less well-defined floral horizons are represented, with a stratigraphic range extending from the lower part of the middle Cretaceous to the upper Eocene—two in Cretaceous and one, or possibly two, in the Tertiary.

Exact correlation of the floras is difficult for the reason that certain associations of diverse elements occur together in some of the collections which were not known elsewhere in any known, or described, floras. Apparently in Alaska many old types persisted long after they had become extinct in other parts of North America and Europe. Cycads of the genera *Zamites*, *Pterophyllum*, and *Podozamites* are found associated with upper Cretaceous and lower Tertiary angiosperms. The logical assumption would seem to be that the older and more primitive types of vegetation, represented by the cycads, had persisted into more recent times, rather than that the highly developed types, represented by the angiosperm genera, had begun far back in the early part of the Cretaceous. It is evident that the Cretaceous and Tertiary floras of Alaska were as distinct from the equivalent Cretaceous and Tertiary floras of the rest of the North American continent as the living floras of the Pacific Coast are from those of the interior.

The paper was illustrated by a map of Alaska and a chart showing the correlation of the floras. E. S. BASTIN, *Secretary.*

RADIO-TELEGRAPHY.—*Condenser losses at high frequencies.*
L. W. AUSTIN, Naval Wireless Telegraphic Laboratory.
To appear in the Bulletin of the Bureau of Standards.

The following experiments have been carried out in the wireless laboratory for the purpose of determining the equivalent resistance of various types of condensers in high frequency circuits.[1]  The method used was to observe the current in a spark circuit containing the condensers under test and then substitute a Fessenden compressed air condenser of approximately the same capacity and add a high frequency resistance sufficient to reduce the current to the same value as that observed with the other condensers.  It was found possible to make these resistance observations with an accuracy of about 0.05 ohm.  Special experiments showed that the resistance of the compressed air condenser under the given conditions was 0.25 ohm, which was probably due to imperfect insulation and eddy currents in the metal case.

Two types of copper coated Leyden jars were furnished by the Wireless Specialty Apparatus Company, and one type each by the Telefunken Company of America and the United Wireless Company.  The Moscicki condensers were of their well known form encased in brass tubes with the glass thickened at the edges of the conducting coating and with these edges covered with an insulating liquid.  The paper condenser was of a well known make.

[1] While the work was in progress a paper on the same subject by Professor Fleming appeared.  See Proc. Phys. Soc. of London, 23: 117.  1911.

The results of the tests with the condensers in air are given in Table I.

### TABLE I

CONDENSERS IN AIR

*Volts = 14,500 (Max.)    Current = 7 to 8 Amps.    Wave-length = 1,000 m. (About)*

|  | NUMBER OF JARS | CAPACITY | ADDED RESISTANCE |
|---|---|---|---|
|  |  | *Mf.* | *Ohm.* |
| Wireless Specialty (1). . . | 3 | 0 00603 | 0 80 |
| Wireless Specialty (2) | 3 | 0 00605 | 0 90 |
| Telefunken | 3 | 0 00612 | 1 30 |
| United Wireless . . | 2 | 0 00603 | 1 55 |
| Moscicki* | 1 | 0 00548 | 0 575 |
| Paper . | | 0 00275 | 2 05 |
| Compressed Air . . . . | | 0 00375 | |

* It is not exactly correct to compare the Moscicki condensers with the jars in air as the insulating liquid covers the edges of its conducting coatings.

Special experiments showed that the slight difference in capacity between the compressed air and the other condensers made no observable difference in the results, the inductance remaining the same.    The paper condenser on account of its small capacity was measured in parallel with a glass condenser of known loss and its resistance deduced from these observations.

Comparisons were also made by the same method between the compressed air condenser and the different sets of Leyden jars, the latter being immersed in a heavy transformer oil, the conditions of the experiment being the same as before.    Here no difference exceeding 0.05 ·ohm was observed between the jars and the compressed air, indicating that the losses in the glass of the jars is small compared with the brushing losses.

Experiments were next tried with the three wireless specialty jars immersed in oil at voltages from 4700 to 18500 (maximum). The circuit containing the jars was the same as above except that there was no spark gap, it being excited by a quenched gap circuit to which it was coupled.    The decrement was determined by means of a wave meter in the usual way.    Table II shows that there was no certain increase observable with increasing voltage.

## TABLE II

| Volts (max). | | | 4700 | 7100 | 11400 | 14500 | 18500 |
|---|---|---|---|---|---|---|---|
| Decrement . .. | | . | 0 0435 | 0 0440 | 0 0445 | 0 0445 | 0 0445 |

Comparisons were next made between three jars in oil and three in air using the added resistance method in a circuit excited by a quenched gap circuit. The results were found to vary according to the cleanliness and nature of the glass in the jars exposed to the air; the difference in resistance in air and in oil being nearly negligible at 4000 volts, and amounting in the Wireless Specialty jars to about 1.4 ohms at 20000 volts. The increase was approximately proportional to the square of the voltage, in agreement with the results of Fleming.

From this follows a conclusion which is contrary to the ordinarily accepted view; that is, that the brushing losses are not reduced by placing jars in series if the capacity and voltage remain the same, for if one jar be replaced by four jars in parallel series, the voltage on each jar is reduced to one-half and the loss per jar to one-fourth. The brushing surface is increased four times therefore the total loss remains the same. This conclusion was proved by experiment to be correct.

Another experimental fact which is not so easily explained is that the losses in jars with only their edges immersed in oil are considerably greater than when the whole conducting surface is covered. This result is opposed to the idea that the air losses lie wholly at the edges of the conducting coatings. This fact has been verified a number of times.

PHYSICS.—*The magnetic rotation and ellipticity for massive metal mirrors.* PAUL D. FOOTE. Communicated by C. W. Waidner. To appear in the Physical Review.

Plane polarized light incident normally upon a mirror of a magnetic substance placed in a magnetic field in which the lines of force are perpendicular to the mirror surface, is, in general, reflected in the form of an elliptic vibration whose axes are inclined at a small angle to the plane of the incident polarization. A series of measurements were made upon mirrors of iron, cobalt, steel,

nickel, invar, magnetite, and Heusler's alloy in the attempt to
establish the magnitude of these effects.

The mirrors, small polished metal plates, were mounted upon
the pole face of a ring magnet capable of producing 25000 c.g.s.
induction. For the measurement of the rotation, a Lippich
half nicol was employed, and for the ellipticity, a Brace Elliptic
Halfshade analyzing system. The magnetic field was calibrated
by the rotation produced on double transmission thru a plate of
glass for which the Verdet constant had been previously obtained.
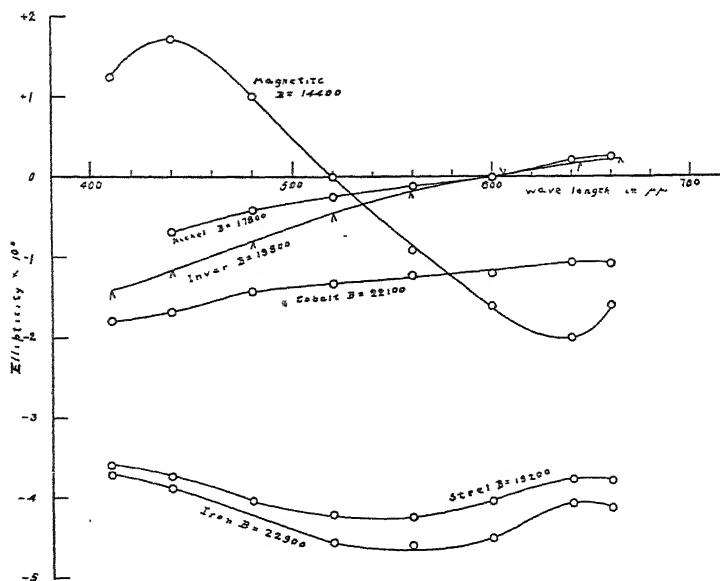


Fig. 1. Ellipticity Dispersion Curves.

The rotatory dispersion curves for the mirrors examined were
in reasonable agreement with the work of preceding investigators,
being negative thruout (contrary to the magnetizing current)
in the case of iron, cobalt, steel, nickel and invar, and in the case
of magnetite, negative in the violet, zero at $454\mu\mu$, and positive
in the red. Heusler's alloy showed signs of an extremely small
negative rotation.

The ellipticity dispersion curves appear somewhat similar to those obtained by transmission thru metallic films. For iron, cobalt, and steel the vibration is negative (contrary to the magnetizing current), while nickel, iron and magnetite show anomalous dispersion, the reflected light being plane polarized at wave length of $600\mu\mu$ for nickel and invar, and $520\mu\mu$ for magnetite   In all of the substances the ratio of minor to major axes was found to be of an order $10^{-3}$.  It is interesting to note the probable influence of the iron in the invar mirror.  The curve closely resembles that obtained for nickel, the points of zero ellipticity being identical, but the magnitude of the effect in invar is greater in the negative portion of the curve and smaller in the positive red.   Heusler's alloy showed a very slight negative ellipticity too small to admit measurement.  The accompanying figure presents several typical ellipticity dispersion curves.

Curves were also obtained showing the variation of both rotation and ellipticity with the magnetic field.  The rotation resembled the I-B type curves as found by Du Bois.  The ellipticity likewise presented this characteristic, and, when intensities of magnetization, easily obtainable from the steep slope and the asymptotic sections of the curve $R = f(B)$, are plotted against ellipticities, the result is a straight line showing a direct proportionality, $E = F \cdot I$.

The work was carried out in the Brace Laboratory of Physics, Lincoln, Nebraska, under the direction of Dr. C. A. Skinner to whom the writer is indebted.                                     .

THERMODYNAMICS.—*The reheat factor in steam-turbine design*.  E. BUCKINGHAM, Bureau of Standards.  Communicated by C. W. Waidner.  To appear in the Bulletin of the Bureau of Standards, 7, No. 4.  1911.

The expansion line of a multistage steam turbine, drawn on the Mollier diagram with total heat, $H$, as ordinate and entropy, $\varphi$, as abscissa, crosses each isopiestic at an angle $\beta$ with the $\varphi$ axis such that

$$- K^2 \tan \beta = \frac{\epsilon}{1 - \epsilon} \theta$$

in which $\epsilon$ is the stage efficiency at the given point in the turbine, $\theta$ is the absolute temperature of the steam at this pressure, and $K^2$ is a constant fixed by the relation of the scales of $H$ and $\varphi$. If the stage efficiency is constant, as may be the case when the turbine has a large number of similar stages, the expansion line is concave upward, because $\theta$ decreases as the pressure and total heat fall.

Let $H_0$ be the total isentropic heat-drop available between the initial state and the final pressure of the steam. Then if the combined efficiency of a number of stages in series were the same as their separate stage efficiency $\epsilon$, the heat drop of the steam in passing through the turbine would be

$$H = \epsilon H_0$$

In reality, the combined efficiency is greater than the stage efficiency because the reheat in each stage except the last is produced at or above the initial temperature of the next following stage, and is partially available for reconversion into work. This fact is expressed on the Mollier diagram, within the saturation field, by the curvature of the expansion line, which ends at a lower point on the final isopiestic than if it had the uniform slope given by

$$- K^2 \tan \beta = \frac{\epsilon}{1-\epsilon} \theta_2$$

in which $\theta_2$ is the temperature of the exhaust. The heat drop in the turbine is therefore expressed by the equation

$$\mathrm{H} = R \, \epsilon \, H_0$$

in which $R$ is the "reheat factor," a quantity slightly greater than unity.

On the very approximate assumption that the isopiestics radiate from a single point, a simple equation may be deduced for the expansion line of wet steam; and it follows from this equation that the reheat factor for the expansion of wet steam between the pressures $p_1$ and $p_2$, at which the absolute saturation temperatures are $\theta_1$ and $\theta_2$ satisfies the equation

$$R = \left[ 1 - \left( \frac{\theta_2}{\theta_1} \right)^\epsilon \right] \div \epsilon \left( 1 - \frac{\theta_2}{\theta_1} \right)$$

The values obtainable from this equation may be computed more conveniently and with sufficient accuracy by an empirical equation of the form

$$R - 1 = (0.975 - \epsilon) \, (\log_{10} \theta_1 - \log_{10} \theta_2) \text{ constant.}$$

A table is given, of values of $R$ for the stage efficiencies $\epsilon = 0.1$, $0.2 - - - 0.8$, and for expansion from 350 lbs. /m² abs. down to various lower pressures. When $(R - 1)$ is plotted against the lower pressure as abscissa, for a given value of $\epsilon$, the value of $(R-1)$ for expansion between any two pressures within the limits of the curve, with this stage efficiency, is equal to the difference of the ordinates of the curve at the two pressures.   Hence if a set of curves be plotted from the data given for the various stage efficiencies, the reheat factor may, by interpolation, be found very expeditiously for the expansion of wet steam between any two pressures and with any stage efficiency.   The curve for $\epsilon = 0.1$ is given and its use illustrated.

A much more exact assumption regarding the distribution of the isopiestics in the saturation field leads to a very complicated expression for $R$, but the values computed in this way are sensibly identical with those found by the simple graphical method described above, which may therefore be regarded as sufficiently exact for use in designing.

MINERALOGY.—*Cuprodescloizite from California.*   WALDEMAR
    T. SCHALLER, Geological Survey.

Some samples of reported vanadium ore, sent to the Survey by A. L. Lombard and J. F. Main, of the Dirigo Mining and Milling Company, of Los Angeles, California, proved to be coated with a deposit of cuprodescloizite.   The associated lead minerals are cerusite and vanadinite from which the cuprodescloizite seems to be derived.   The locality is given as Camp Signal in San Bernardino County, California.

A qualitative chemical test showed the presence in quantity of lead, copper, zinc, vanadium and a little water.   A direct quantitative determination of the vanadium gave 21 per cent of $V_2O_5$.

The material, when examined under the microscope, was seen to be well crystallized in minute, colorless or pale yellow plates. Some of these are square or oblong, others are irregularly shaped. The rectangular plates give parallel extinction, with the axial plane parallel to one of the sides. The axial angle is very large. The thicker pieces are very slightly pleochroic in shades of yellow. The double refraction is not very high. A few tabular pieces showed an acute termination, the sides of which are inclined 52° to the trace of the axial plane. Sections tabular parallel to $a\{100\}$ show $c\{001\}$, $u\{011\}$, both large, and $b\{010\}$, small.

MINERALOGY.—*Crystallized variscite from Utah.* WALDEMAR T. SCHALLER. To appear in a bulletin, "Mineralogical Notes, Series II." of the Geological Survey.

A sample of crystallized variscite from Lucin, Utah, collected by Mr. D. B. Sterrett, furnished material for a determination of the chief properties of the mineral The bright green tabular crystals are orthorhombic and in form similar to those of the analogous minerals scorodite and strengite, and of phosphosiderite, which is held to be identical with strengite. Three different orientations are possible for the variscite crystals and these are described and their availability discussed. The optical relation of barrandite to strengite and variscite is also considered.

Some of the variscite crystals have included regular groupings of small, variously oriented and irregularly shaped particles of the same mineral. The green crystals are only slightly pleochroic but on being heated before the blowpipe or up to 160° C., when all the water is given off, the mineral becomes deep lavender with strong pleochroism from violet to lavender. The mean refractive index (1.560) and the birefringence (0.032) of the green crystals drop to 1.448 and 0.003 respectively, after heating. The dehydrated, lavender-colored material is now, unlike the original green-colored mineral, readily soluble in acids.

The chemical analysis shows that small quantities of chromium, vanadium, and iron are present but no adequate explanation of

the color changes has been found.   The analysis and ratios are as follows:

*Chemical analysis of variscite*

| | | | |
|---|---|---|---|
| $H_2O$ . | 22.68 | 1 260 | 4 00 |
| $P_2O_5$      . . . | 44.73 | 0.315 | 1 00 |
| $V_2O_3$  .. | 0.32 | 0 002 | |
| $Cr_2O_3$  . | 0.18 | 0 001 | |
| $Fe_2O_3$      .   . . . . | 0 06 | | 1.02 |
| $Al_2O_3$    . . | 32.40 | 0.318 | |
| Ni, Co, Cu, Mn, As,<br>  Ca, Mg,...   ..    ... | none | | |
| | 100.37 | Density = 2 54 | |

The ratios lead to the accepted formula $Al_2O_3 \cdot P_2O_5\ 4H_2O$.

MINERALOGY.—*Chemical composition of the French phosphorite minerals.* WALDEMAR T. SCHALLER.   To appear in a bulletin, "Mineralogical notes, Series II." of the U. S. Geological Survey.

The mineralogy of the French phosphorite deposits has been fully described by Lacroix in two recent publications.[1]   He shows that the three minerals of which these phosphorites are composed are collophanite, dahllite (*syn.* podolite) and francolite (*syn.* staffelite).   The formulas of these minerals, as generally given, are as follows: for dahllite $6CaO\ 2P_2O_5\ CaCO_3\ \frac{1}{2}H_2O$; for francolite $10CaO \cdot 3P_2O_5 \cdot CaF_2 \cdot CO_2 \cdot H_2O$;   and for collophanite $3CaO\ P_2O_5$.-$H_2O$ (Dana) or, since $CO_2$ has been shown to be an essential constituent of the mineral, $x[3CaO\ P_2O_5]$ or $x[9CaO\ 3P_2O_5 \cdot CaF_2]$ $+ yCaCO_3 + zH_2O$ (Lacroix).

A study by the writer of the analyses of these minerals has shown that their formulas are more probably as follows:   dahllite $9CaO\ 3P_2O_5 \cdot CaO \cdot CO_2 \cdot H_2O$, francolite $9CaO\ 3P_2O_5\ CaF_2 \cdot CO_2$·$H_2O$ and collophanite $9CaO\ 3P_2O_5 \cdot CaO\ CO_2 \cdot H_2O + nH_2O$.

[1] Comptes rendus, 150: 1213.   1910; Minéralogie de la France, 4:   555.   1910

# ABSTRACTS

METEOROLOGY.—*Summary of the free air data at Mount Weather for the three years, July 1, 1907 to June 30, 1910.* WM. R. BLAIR. Bulletin Mount Weather Observatory, 4: 25–63. 1911.

The data consist of the air pressures, air temperatures and wind directions observed above Mount Weather in 1013 ascensions, 896 with kites and 117 with captive balloons. Related surface data and weather conditions are also included.

Air pressures have been used only in the determination of altitudes.

Air temperatures have been considered in two ways; (1) By months and seasons, (2) According to surface air pressure, by seasons and quadrants in high and in low pressure areas. For the purpose of this summary, the bounding isobar of the high pressure areas is taken as 764.5 mm. of mercury; of low pressure areas, 759.5 mm. The quadrants are numbered counterclockwise, I being in front of the area and to the left of a line thru the center and lying in the direction of motion of the area.

Those wind directions observed within areas of high and low pressure have been grouped by octants and distance from the center of the area at levels 1000 meters apart. The octants are numbered in the same way as the quadrants. The wind directions not well within high or low pressure areas are tabulated in three groups depending on the location of maximum and minimum pressure with reference to Mount Weather.

All means are graphically represented besides being tabulated. The number of observations represented in each mean is shown.

It has been the writer's purpose to group these data so that the conclusions to be drawn from them would be evident with the minimum amount of comment. In the brief discussion accompanying the tables and diagrams, the distribution of the observations in their respective groups is considered, also the value as normals of the means obtained

from the first arrangement of the temperatures. In connection with the second arrangement of temperatures and the wind directions, are some remarks upon the dynamics of the lower strata of the atmosphere over high and low pressure areas.                          W. R. B.

METEOROLOGY.—*Free air data at Mount Weather for January, February and March, 1911.* WM. R. BLAIR. Bulletin Mount Weather Observatory, 4: 65–102. 1911.

Eighty-six ascensions were made at Mount Weather in these three months, 83 by means of kites and 3 by means of captive balloons. The average altitude reached was 2840 meters above sea level. ˙Obervations were made of air pressure, air temperature and wind direction. The data in detail are published in tabular form. The temperature and wind direction aloft are graphically summarized in six Charts, and the surface temperatures at Mount Weather and at the two valley stations, Trapp and Audley, in three figures.                          W. R. B.

ELECTRICITY.—*A comparison of American direct-current switchboard voltmeters and ammeters.* T. T. FITCH and C. J. HUBER. Bulletin Bureau of Standards 7: 407–422. 1911.

This paper is an analysis of the various factors of performance and details of construction of direct-current switchboard voltmeters and ammeters. All American makers of standard sizes of such instruments were given an opportunity to submit samples.

The voltmeters all showed maximum errors of calibration less than one per cent of full scale reading, while the ammeters showed maximum errors of from two to six per cent. The ammeters are more subject to errors than are voltmeters owing to the necessity of working them on the low electromotive force permissible at the terminals of the shunts. The details of performance and the constants of construction are tabulated.

The general lines of design are very similar in all the instruments, which may be taken as typical not only of American, but also of European direct-current practice. The most decided departure from type is in the use of the single air gap in the instruments of one maker. Further improvements in direct-current switchboard instruments are to be looked for mainly in the refinement of details of design and construction.                          T. T. F.

AGRICULTURAL PHYSICS.—*The electrical bridge for the determination of soluble salts in soil.* R. O. E. DAVIS and H. BRYAN. Bulletin Bureau of Soils, No. 61. 1911.

The bulletin contains a complete description of the modified Wheatstone bridge as used by the Bureau of Soils with considerable experimental data on its efficiency. Working drawings and cuts of the instrument are included in the description. Conclusions reached from the experiments are: Difference in texture of soils influences the resistances of the soil; the presence of carbonates changes the resistance so greatly that with black alkali a special table must be used; organic matter in large amounts increases the resistance, the same amount of salt being present; and when a soil is in a dry condition, at least twenty minutes should elapse after moistening before the reading for resistance is made.

R. O. E. D. and H. B.

AGRICULTURAL CHEMISTRY.—*The isolation of creatinine from soils.* EDMUND C. SHOREY. Science 33: 340. 1911.

Creatinine has been isolated from several soils by the following method. An extract made by shaking the soil for half an hour with 2 per cent sodium hydroxide is neutralized with acetic acid and filtered. To the filtrate a small quantity of dextrose is added, after heating to boiling, Fehling's solution is added until the precipitate formed is red. The precipitate after washing is decomposed with hydrogen sulphide concentrated under reduced pressure. Creatinine, if present in the soil, is in this filtrate together with purine bases. It can be separated as creatinine zinc chloride and creatinine prepared from this by treatment with lead hydroxide. The creatinine was identified by the characteristic crystalline appearance of the zinc chloride compound and by the Jaffé, Weyl and Salkowski color reactions.    M. X. SULLIVAN.

AGRICULTURAL CHEMISTRY.—*Reduction by roots.* OSWALD SCHREINER and M. X. SULLIVAN. Botanical Gazette, 51: 121. 1911.

Plant roots have the power to reduce sodium tellurite and selenite to metallic tellurium and selenium. The reducing action of the growing root is stronger in the young seedling, being much stronger in a seedling four days old than in one twelve days old.

As judged by the quickness with which the selenium deposits on the roots and the extent and intensity of the deposit, the reducing power

increases from the time of germination to the sixth or eighth day and then decreases. It is most marked intracellularly in the parenchyma cells of the root tip. A faintly acid reaction stimulates the reducing power. No reducing enzyme could be extracted from the crushed plants.

M. X. S.

AGRICULTURAL CHEMISTRY.—*Concurrent oxidation and reduction by roots.* OSWALD SCHREINER and M. X. SULLIVAN. Botanical Gazette, 51: 273. 1911.

The power of growing wheat roots to oxidize easily oxidizable substances such as aloin, and to reduce sodium selenite and tellurite may run independently or concurrently. A faintly alkaline reaction favors oxidation, a faintly acid reaction reduction. Within certain limits the two processes may occur together. Reduction seems to be connected with the inner metabolism of the plant and is probably brought about by non-enzymotic compounds analogous to the organic hydroxyacids and their salts, which have a slight reducing action, or to compounds unsaturated in respect to oxygen. Oxidation is due to bodies capable of fixing atmospheric oxygen in an active form, perhaps as peroxides, which is secondarily transferred to others. Reduction processes are predominant in the early stages of the seedlings' growth but are less manifest as these develop and oxidation becomes predominant. Oxidation is the prominent property of the plant root.                    M. X. S.

AGRICULTURAL CHEMISTRY.—*Oxidation in soils.* M. X. SULLIVAN and F. R. REID. Journal of Industrial and Engineering Chemistry, 3: 25–30. 1911.

It has been found that soils have an oxidizing power, which varies with different soils. In general those of better producing powers have the better oxidation power.

In studying oxidation processes by the use of easily oxidizable substances like aloin, pyrogallol, hydroquinone, h-phenylenediamine, benzidine, guaiac and a-naphthylamine, the authors found aloin to be the best reagent.

Reducing agents such as hydroxylamine HCl, oxalic acid, sodium thiosulphate and formalin completely check oxidation while such antienzymotic substances as mercuric chloride, silver nitrate, and carbon bisulphide have little if any retarding action.

All soil samples tested with the exception of Orangeburg loam have their oxidative powers considerably checked by a temperature of 105° C. dry heat and by steam sterilization in an Arnold sterilizer. The oxidative powers on all soils are completely destroyed by incineration. The mineral acids have very little effect in restoring this function while the organic hydroxyacids, especially citric acid, are very effective in this regard.

The hydroxyacids tend to increase the oxidative power on normal soils, while the related non-hydroxyacids have little effect.

Manganese dioxide increases the oxidative power somewhat. The salts of manganese, iron, aluminum, calcium, and magnesium have little effect alone, but in the presence of simple hydroxyacids they increase the oxidative function considerably.

The subsoils of soils having marked oxidative powers seldom have the same property. The effect of cropping and of fertilizers is variable. Oxidation in soils is comparable to that in plants and animals, and is due mainly to non-enzymotic forces, inorganic and organic, working separately, conjointly, or in reinforcing or activating combination.

M. X. S. and F. R. R.

AGRICULTURAL CHEMISTRY.—*Paraffin hydrocarbons in soils.* OSWALD SCHREINER and EDMUND C. SHOREY. Journal of the American Chemical Society, **33**: 81. 1911.

A paraffin hydrocarbon from a peat soil was isolated and identified as hentriacontane $C_{31}H_{64}$. Since this compound has been found in a number of plants and nothing is known regarding the possibility of its formation from other organic matter in soil the conclusion is reached that it may be an unchanged plant residue.                    E. C. S.

AGRICULTURAL CHEMISTRY.—*Glycerides of fatty acids in soils.* OSWALD SCHREINER and EDMUND C. SHOREY. Journal of the American Chemical Society, **33**: 78. 1911.

There was isolated from a sample of soil (Elkton silt loam) a glyceride liquid at room temperature. This gave on saponification oleic acid and some unidentified solid fatty acids. The conclusion is that the glyceride is a plant residue that has resisted decomposition in the soil.

E. C. S.

GEOLOGY.—*The geology of the Lake Superior Region.* C. R. VAN
HISE and C. K. LEITH. Monograph U. S. Geological Survey No.
52. Pp. 630, with maps, sections, and views. 1911.

This monograph gives the first connected account of the geology of the
Lake Superior region as a whole, with special reference to the iron-bear-
ing and copper-bearing formations. Attention is directed primarily to
the correlation of the formations, to the geologic history of the region,
and to the origin of the ores. In addition, there are brief chapters on
parts of the district which had not previously been reported on by the
United States Geological Survey.

The Lake Superior region, comprising approximately 181,000 square
miles, includes three topographic provinces: (1) the peneplain of the
Lake Superior highlands; (2) a series of lowland plains surrounding
the peneplain on the east, south, and west; and (3) the deep basin of
Lake Superior. These provinces are in various stages of development
and preservation.

The Pleistocene epoch is treated in four stages: (1) preglacial time.
when the topography was much as it is now except for certain valleys
that were later deepened by glacial erosion, broad areas that were after-
wards covered by glacial drift, and an entire contrast of drainage; (2)
the time of advancing glaciers, when the land was gradually being covered
and eroded by an ice sheet, drainage was being modified, and plants
and animals were being driven out; (3) the time of retreating glaciers,
when from an extreme stage of glaciation with only the Driftless Area
uncovered the present topography was revealed by the gradual melting
of a largely stagnant ice sheet; (4) the present stage of modification of
glacial deposits, building of stream and lake deposits, return of plants
and animals, and a general tendency toward the restoration of the con-
ditions that prevailed before glaciation.

The lowest rocks found in the region are those of the Archean system
or basement conplex, consisting of the Keewatin and Laurentian series.
These are overlain successively by the Keweenawan and Huronian series,
which together make up the Algonkian system. In certain districts the
Huronian is separable into two or three divisions, marked by uncon-
formities. None of these formations is fossiliferous. The Keewatin
series, where relatively unchanged is remarkably uniform in character,
and even the metamorphosed portions show features that indicate ori-
ginal identity with the less altered portions. The Keewatin comprises
a dominant igneous formation and a subordinate sedimentary formation.

The Laurentian series is represented by great masses of granite, granitoid gneiss, and syenite. Intermediate and basic rocks are subordinate. The Laurentian intrudes the Keewatin series in masses ranging from great batholiths many miles in diameter to dikes and minute injections. It appears that the Archean was a period of regional igneous activity, igneous rocks making up more than 90 per cent of the whole. This activity, both plutonic and volcanic was on a tremendous scale.

The Algonkian system on the whole contrasts with the Archean in being dominantly sedimentary, in being less metamorphosed, in having a distinctly recognizable stratigraphic sequence, and in topography. A subaërial deposition is regarded probable for the Keweenawan and the lower Huronian of the North Shore. The upper Huronian, the greatest carrier of iron ore, is regarded as a delta deposit. The iron-bearing formations are regarded as having been derived partly from submarine volcanic rocks, in magmatic solutions, or by the reaction of hot volcanic material with sea water, or by weathering, or by some combination of these methods. The Algonkian system comprises in its fullest development four unconformable divisions—lower Huronian, middle Huronian, upper Huronian, and Keweenawan.

For the most part the formation which overlies the Proterozoic rocks is a nearly horizontal sandstone, generally recognized as Cambrian. In general, the relations between this sandstone and the Proterozoic rocks are those of most profound unconformity, except where Keweenawan sandstones are the underlying beds.

Of the several periods of deformation, three stand out conspicuously —that at the close of the Archean, throughout the region; that at the close of the lower-middle Huronian, mainly on the north shore; and that at the close of the Keweenawan on the south shore. As a result of these successive deformations the Lake Superior region is essentially an asymmetric synclinorium with nearly east-west axis. The copper ores of the Keweenawan are regarded as directly related to contemporaneous volcanism.

Iron ores occur in a large number of the pre-Cambrian stratigraphic subdivisions. The iron-bearing formations consist essentially of interbanded layers of iron oxide, silica, and combinations of the two, variously called jasper or jaspilite (where anhydrous and crystalline) and ferruginous chert, taconite, or ferruginous slate (where softer and more or less hydrous). These rocks become ore by local enrichment, largely by the leaching out of silica and to a less extent by the introduction of iron oxide. There are accordingly complete gradations between them and the iron

ores. One of the most significant variations with reference to the origin of the ore is in the relative abundance of greenalite rocks and siderite.

The average original iron content of the iron-bearing formations, that is, of the siderite and greenalite phases, exclusive of interbedded slates, as shown by all available analyses, is 24.8 per cent and of the ferruginous cherts and jaspers, from which there has been but little leaching of silica, 26.33 per cent. The amphibole-magnetite phases of the formations show approximately the same percentage. The average iron content of the formations, as shown by all available analyses, different phases, including the ores, being taken in proportion to their abundance, is 38 per cent. A comparison of this figure with 24.8 per cent for the orginal siderite and greenalite and 26.33 per cent for the ferruginous cherts and jaspers from which silica has not been removed shows what secondary concentration has accomplished. It is possible, however, that the ores have in part been derived from the richer portions of the iron-bearing formations. So far as this is true, the concentration has been less than these figures indicate. The iron ores form but a very small part of the rocks of the iron-bearing formations.

The following theses bear on the genesis of the iron ores: (1) These ores are altered parts of chemically deposited sedimentary formations that originally consisted mainly of cherty iron carbonate and greenalite. (2) A few of the iron-ore deposits represent originally rich layers in which secondary concentration has made only minor changes. (3) In by far the greater number of deposits, including all the larger ones, secondary concentration has been the essential means of enriching iron-formation layers to ores. (4) The conditions of sedimentation of the iron formation may be roughly outlined. (5) The weathering and erosion of bedrock surfaces of average composition is inadequate as a source of the materials of the iron-bearing sediments; these materials have been derived largely from basic igneous rocks. (6) Some of the sedimentation accompanied or immediately followed each introduction of pre-Cambrian basic igneous rocks into the outer zone of the earth and some took place later under ordinary weathering conditions. (7) The chemistry of deposition under such conditions may be approximated and the original phases of the sedimentary iron-bearing formations may be synthesized in the laboratory. (8) The subsequent oxidation of the iron-bearing formations, the transfer of iron salts, and the leaching of silica by agents carried in meteoric waters have concentrated the ores in all but an insignificant portion of the deposits now mined. (9) This second concentration has been localized by structural and topographic conditions.

(10) In some places before, and in other places after, concentration the iron-bearing formations have been extensively modified by deformation or by igneous contact effects such as tend to prevent further concentration. (11) The sequence of events in the formation of the ores may be outlined for each district and for the region as a whole. (12) The development of the ores in general represents a partial metamorphic cycle.

The iron-bearing formations are bedded and locally cross-bedded and contain recognizable sedimentary material, such as iron carbonate, greenalite, shale, sand, and conglomerate. The orignial constituents of the iron-bearing formations were dominantly cherty iron carbonate and iron silicate (greenalite), with minor quantities of hematite and magnetite and with varying amounts of mechanical sediments.

The close association of iron-bearing sediments with contemporaneous basic eruptive rocks in the Lake Superior region and in other parts of the world, the richness of these eruptive rocks in iron salts, and the probable derivation of the upper Huronian slates associated with the iron-bearing formations from the eruptions make it likely that these iron-rich eruptive rocks were the principal source of the iron in the iron-bearing sediments. As to the manner in which the iron was transferred from the eruptive rocks to the place of sedimentation, there are several hypotheses: (1) It may have been transferred in hot solutions migrating from the eruptive material during its solidification and carrying iron salts from the interior of the magma; (2) so far as the lavas were subaerially extruded, iron may have been transferred by the action of meteoric waters, either hot or cold, working upon the crystallized iron minerals of the rock; (3) the iron may have been transferred by direct reaction of the hot magma with sea water, in which the iron-bearing sediments were deposited.

The essentially new features of the monograph are: (1) a much more detailed and quantitative study of the secondary concentration of the iron ores than has before been attempted; (2) the establishment of genetic relationship between the primary iron-bearing beds and contemporaneous volcanism; (3) the interpretation of structure on a broad scale as indicating the Lake Superior region to be essentially an old shore line of heavy deposition, mountain-making, and volcanism; (4) the correlatio nof the iron and copper deposits of the Lake Superior region, as well as the nickel, cobalt, and silver deposits in Ontario to the east, as all related to volcanism, along an axis of folding parallel to the Lake Superior syncline, all in the region of heavy shore line deposition in pre-Cambrian times.                                                     C. K. L.

AGRICULTURE.—*Soil erosion*, W J McGEE. Bulletin Bureau of Soils, No. 71. Pp. 60, pls. 33. 1911.

The destructive erosion of soils is treated as an abnormal condition in the relation between soil and water and the treatment is introduced by an outline of the normal work of water. The soil is considered as of three parts, viz., soil-body, soil-fluid, and soil-gas; and its efficiency (measured by productivity) is ascribed primarily to physical conditions permitting free circulation of the fluid and gaseous parts through the soil body and into growing crops. A working coefficient for the agricultural duty of water is brought out, i.e., the production of one-thousandth part of its weight in useful plant crop. The duty of soil, measured in terms of the first acre-foot, is also defined as the annual production of one-three hundred thirty-third of its weight of useful plant crop. The normal work of water is sculpturing the land surface and producing vegetal cover in a state of nature is analyzed and compared with the work of water under the conditions attending settlement and cultivation of the country; and it is shown that destructive erosion is one of the consequences of interference with natural conditions. The development of erosion following deforestation and injudicious cultivation is illustrated by photographs reproduced in the plates. Remedies for such erosion are described and illustrated; they include treatment of the soil, treatment of the cover, and treatment of slopes, in such manner as to tend toward restoration of the normal interrelations between natural water supply, cover, and slope—the specific aim of the treatment in each case being such improvement in cultivation as to yield immediate profit, coupled with progressive increase in value of the land treated. W J M.

FORESTRY.—*The Olympic National Forest: its resources and their management.* FINDLEY BURNS. Forest Service Bulletin No. 89. Pp. 20, with map and illustrations. 1911.

The Olympic National Forest in northwestern Washington, with an area of 1,594,000 acres, contains one of the heaviest stands of timber in the United States. It approximates 25,500,000,000 board feet, and the Forest is capable of producing a sustained annual yield of 250,000 board feet. Douglas fir, western hemlock, amabilis and grand fir, and Sitka spruce are the principal species. Present conditions in the lumber industry in the northwest would make it unwise to cut each year the amount of timber the Forest is capable of yielding. The Olympic Forest was set apart to establish a timber reserve which could be drawn

upon for a supply when the immense stands on private holdings have been cut away. Plans made for logging in the Forest for the next ten years contemplate a cut during that period of 300,000,000 board feet.

While the Forest contains some mountain meadows, present conditions are almost prohibitive of stock raising. Without the heavy forest cover to check the swift runoff of the enormous winter rainfall, much land on the Olympic Peninsula would be likely to suffer serious damage. Extensive waterpowers await development, and the dense cover will be of the utmost importance in preventing alterations in the character of the streamflow. There is practically no mining development on the Forest at present though both gold and copper have been found. The region offers little opportunity for agriculture. F. B.

HELMINTHOLOGY.—*Some known and three new endoparasitic trematodes from American fresh-water fish.* JOSEPH GOLDBERGER, U. S. Public Health and Marine-Hospital Service. Bulletin Hygienic Laboratory No. 71. 1911.

*Leuceruthrus micropteri* originally described by Marshall and Gilbert, 1905, is redescribed and some new points are added to the original description. It is probable that the genus *Leuceruthrus*, of which this is the type and only species, will be found to represent the type of at least a new subfamily, *Leuceruthrinae*, and probably of a new family, *Leuceruthridae* of the superfamily *Fascioloidea*.

Two new species of *Azygia*, namely, *A. acuminata* and *A. bulbosa* are described and some new points in the anatomy of *Azygia loossii* Marshall and Gilbert, 1905, are added to the original description. A key to the species of the genus is given, but it does not include *Azygia sebago* Ward, 1910. The latter species is evidently very close to *A. bulbosa*.

The genus *Hassallius* is created for a new species, *Hassallius hassalli* from the stomach of *Ambloplites rupestris*.

*On some new parasitic trematode worms of the Genus Telorchis.* JOSEPH GOLDBERGER. Bulletin Hygienic Laboratory No. 71.

The author considers *Telorchis poirieri*, Stossich, 1904 to be distinct from *Dist. poirieri* (= *Dist. gelatinosum* Poirier) Stossich, 1895 and proposes for it the name *Telorchis (cercorchis) stossichi*. Two new species are described and a key to the species of *Telorchis* is given.

*A new species of Athesmia (A. foxi) from a monkey.* JOSEPH GOLDBERGER and CHARLES G. CRANE. Bulletin Hygienic Laboratory No. 71.

The trematode genus *Athesmia* for many years included only the single species described by Braun in 1899 under the name of *Distomum hetero-*

*lecithodes.* The new species described by Goldberger and Crane is the second species to be placed in this genus. It resembles Braun's form very closely, but differs in being more slender, in having relatively shorter ceca, in that the gut crosses at the equator of the vitellarium, and in that the vitellarium is more frequently on the right side of the body.

*A New Trematode (Styplodora Bascaniensis) with a blind Laurer's canal.* JOSEPH GOLDBERGER. Proceedings U. S. National Museum 40:233–239. 1911.

The new species described stands close to *Styphlodora solitaria* Looss and is of special interest because of the peculiarity of its Laurer's canal. Instead of opening on the surface as with only one exception heretofore known it always does, this duct ends blindly as a globular body of about the size of the ovary very much as has been described for *Aspidogaster conchicola.* This globular cecal end contains spermatozoa, sperm, morulas, round deeply staining bodies suggesting nuclei, and a few vitelline cells. J. G.

CONCHOLOGY.—*The recent and fossil mollusks of the genus Bittium from the west coast of America.* PAUL BARTSCH. Proceedings U. S. National Museum, **40**: 383–414, pls. 51–58. 1911.

This is a monograph of the west American members of this genus, containing descriptions of the new sub-genus *Lirobittium.*

The following species and subspecies are described as new: (*Bittium*) *panamense, johnstonæ, (Semibittium) attenuatum boreale, attenuatum latifilosum; subplanatum, nicholsi; (Lirobittium) catalinense inornatum, ornatissimum munitoide, asperum lomaense, cerralvoense, (Semibittium) larum, Bittium oldroydæ, fetellum, giganteum, casmaliense, arnoldi,* and *mexicanum.* P. B.

CONCHOLOGY.—*New mollusks of the genus Aclis from the North Atlantic.* PAUL BARTSCH. Proceedings U. S. National Museum, **40**: 435–438, Pl. 59. 1911.

*Aclis dalli, cubana, rushi, floridana, verrilli* and *carolinensis* are described as new. P. B.

FISHERIES.—*Natural history of the American lobster.* FRANCIS
  HOBART HERRICK, Western Reserve University.  Bulletin Bureau
  of Fisheries, 29: 149–408, pls. 28–47.  1911.

After a preminary chapter upon the zoological relations, habits and
development of the lobsters and allied Crustacea, the author deals
first with the lobster in aspects of its economic importance—history and
methods of the fisheries, instincts and behavior of the animal and effect
of external conditions in relation to abundance.  Growth and size are
discussed with reference to tradition and fact, and the process of molting
is the subject of a long fourth chapter, followed by an account of the
enemies of the lobster, parasites and messmates, diseases and fatalities.
The ensuing major portion of the work is occupied with the anatomy,
embryology and physiology of *Homarus americanus*, a full chapter being
given to the great forceps, another to the phenomena of defensive mutila-
tion and regeneration.  Reproduction, development and rate of growth
are discussed at length with emphasis upon their significance in relation
to the lobster fisheries and lobster culture, and the book concludes with
a most practical discussion of methods of preservation and propagation
of the lobster.

Professor Herrick's conclusions and recommendations endorse the
theories and practices of Dr. A. D. Mead in his lobster-culture work for
the Rhode Island Fish Commission, the essential feature of which is the
rearing of artifically-hatched fry to the self-protective stage before liber-
ating them; and Professor Herrick also supports the arguments of Dr.
George W. Field, of the Massachusetts Board of Fish Commissioners in
regard to lobster laws.  He criticizes and deprecates the prevalent
measures consisting of closed seasons, gage limits, and the planting of
artificially hatched fry.  Closed seasons are futile because they do not
cover the ten-month and variable spawning period of the lobster; owing
to the increasing productiveness of the female lobster from year to year,
by leaps which bring the number of eggs from 10,000 at the 10-inch
size to 100,000 at 16 inches, the legalized destruction of all adults over
9 and 10 inches is a methodical proscription of the most indispensable
element in the race; while, since the lobster's rate of survival is probably
but 2 in 30,000, it would appear that all of the millions of lobster fry
planted on the coast of New England and the Provinces during the last
ten years would have had to be multiplied by 1250 to maintain the fishery
barely at equilibrium by this means.  "If we would preserve this fishery,"
says Professor Herrick, "we must reverse our laws, as Doctor Field has

ably pointed out, and follow the principles of breeders of domestic animals everywhere—use the smaller and better animals for food, and keep the older, and in this case by far the most valuable, for propagation." Specific suggestions on these points are as follows:

1. Adopt a double gage or length limit, placing in a perpetual close season or protected class all below and all above these limits. Place the legal bar so as to embrace the average period of sexual maturity, and thus to include what we have called the intermediate class of adolescents, or smaller adults. These limits should be approximately 9 inches and 11 inches, inclusive, thus legalizing the destruction of lobsters from 9 to 11 inches long only when measured alive. In this way we protect the young as well as the larger adults, upon which we depend for a continuous supply of eggs. The precise terms of these limits are not so vital, provided we preserve the principle of protecting the larger adults.

2. Protect the "berried" lobster on principle, and pay a bounty for it, as is now done, whether the law is evaded or not, and use its eggs for constructive work, or for experimental purposes with such work in view.

3. Abolish the closed season if it still exists; let the fishing extend throughout the year.

4. Wherever possible, adopt the plan of rearing the young to the bottom-seeking stage before liberation, or coöperate with the United States Bureau of Fisheries or with sister states to this end.

5. License every lobster fisherman, and adopt a standard trap or pot which shall work automatically, so far as possible, in favor of the double gage, the entrance rings being of such a diameter as to exclude all lobsters above the gage, and the slats of the trap of such a distance apart as to permit the undersized animals to escape.

There is appended a bibliography of 329 titles. The plates are chiefly anatomical and diagrammatic, but three of them picture the young lobster in its life colors. E. M. SMITH.

ETHNOLOGY.—*The Hoffman Philip Abyssinian Ethnological Collection.* WALTER HOUGH. Proceedings U. S. National Museum, 40: 265–276, 22 plates. 1911.

A description of rare Abyssinian specimens deposited in the United States National Museum by the Honorable Hoffman Philip, former minister and consul-general of the United States at Addis Abeba, consisting of metal work, basketry, paintings, manuscript, costume, etc., which are interesting survivals of an earlier and higher civilization around the eastern Mediterranean. W. H.

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AGRICULTURE.—*Soils of the eastern United States and their use*. 1911. Circulars of the Bureau of Soils as follows:
*No. 22—Norfolk fine sandy loam. No. 23—Norfolk fine sand. No. 24—Portsmouth sandy loam. No. 25—Sassafras silt loam. No. 27—Cecil sandy loam No. 28—Cecil clay.*

AGRICULTURE.—*Soil Surveys.* (Advance Sheets—Field operations of the Bureau of Soils, 1910) as follows:
*Eastern Puget Sound Basin, Wash.* (Reconnaissance.) A. W. MANGUM. Pp. 90. 4 Maps.

PHYSICS.—*The "correction for emergent stem" of the mercurial thermometer.* E. BUCKINGHAM. Communicated by C. W. Waidner. To appear in the Bulletin of the Bureau of Standards.

In defining the scale of the mercurial thermometer it is assumed that the thermometer is all at the same temperature, as is the case with "total immersion" in a bath of uniform temperature. When a thermometer is standardized, the corrections are nearly always stated for total immersion and in terms of the standard gas scale of the laboratory where the test is made. If, subsequently, the thermometer is used with only partial immersion, the mean temperature of the emergent stem will be different from the temperature of the bulb which it is desired to determine; and to allow for this departure from the condition of total immersion, a "stem correction" must be applied to the observed reading before the corrections given by the standardization become applicable.

The length, $\Delta$, of this stem correction is given by the equation

$$\Delta = l\,(t-f)\,\alpha \dots\dots\dots\dots\dots\dots\dots(1)$$

and its value, $K$, in degrees, by the equation

$$K = nl\,(t-f)\alpha \dots\dots\dots\dots\dots\dots(2)$$

in which $n$ is the number of degrees per unit length of the stem at the level where the reading is made, $l$ is the length of the emergent stem, $t$ is the true temperature of the bulb, and $\alpha$ is the mean

coefficient of apparent expansion of mercury in the glass of which the stem is made between $t°$ and $f°$, both of which are to be expressed in terms of the scale used during the standardization. The correction is often of importance and may in extreme cases exceed 30° C. The two chief methods for determining it are those described by Guillaume and Mahlke.

In Guillaume's method, the quantity $\Delta$ is determined directly as a length. An auxiliary stem similar to a portion of the working stem, closed at both ends, partly filled with mercury, and provided with a scale of equal parts, is placed parallel and close to the working stem and with its meniscus at the same level as that in the working stem. The auxiliary stem must be long enough that its lower end reaches into the region of uniform temperature containing the bulb of the main thermometer, and the mean temperature of the mercury column in the auxiliary stem is then very nearly equal to that of the neighboring column of the same length in the working stem. If the auxiliary stem were now totally immersed the change in its reading would evidently be the desired value of $\Delta$.

If the conditions are such that total immersion of the auxiliary stem is possible the determination of $\Delta$ becomes extremely simple. The scale reading of the auxiliary stem is taken in the position described above. The instrument is then totally immersed, left a short time to take the temperature of the bath, raised again just far enough for observation of the meniscus, and read immediately. The glass of the stem being thick and a poor conductor, this second reading is very nearly the exact reading for total immersion. The difference of the two readings is the value of $\Delta$ in terms of the scale on the auxiliary stem.

If total immersion at the time of use is not possible, the auxiliary stem may be standardized separately and once for all by total immersion in baths of known temperatures, so that its reading for total immersion at any temperature $t°$ may be found from a table. If $t$, which is the desired temperature, is known approximately, an approximate value of $\Delta$ may be found from a single reading and the table. Greater accuracy requires a second approximation by using a corrected value of $t$. For very accurate

work the auxiliary stem must be made of the same glass as the working stem so that the two may be thermally as well as geometrically similar and similarly placed.

In Mahlke's method the correction is not measured directly as a length but is computed from equation (2). The mean temperature, $f°$, of a length $l$ of the working stem, including the emergent part, is measured by a special "fadenthermometer" devised by Mahlke for this purpose. The fadenthermometer has a long, cylindrical, thick-walled bulb of similar dimensions and construction to a portion of the working stem, and is provided with a still finer graduated capillary stem. When in use, it is placed parallel and close to the working stem, with the upper end of its bulb at the level of the meniscus in the working stem. The length $l$ in equation (2) is thus identical with that of the fadenthermometer bulb. If the fadenthermometer has been standardized by total immersion, its reading gives the mean temperature, $f°$, of its bulb and therefore that of the adjacent length $l$, of the working stem, for use in equation (2). The fadenthermometer may be regarded as an auxiliary stem provided with a magnifying device —the still finer capillary stem—for increasing the sensitiveness and reducing the reading errors.

The theory of the use of the fadenthermometer presents some difficulties, and the results obtained by it are subject to several small errors which are not easily estimated or determined and which while not of importance in ordinary work, may become so in work of the highest accuracy. In the more extended form of this paper the theory is discussed at some length. In addition, data on the values of $a$ for several thermometer glasses are given in convenient tabular form for practical use, and suggestions are given for the selection of the most suitable fadenthermometer for use in a given piece of work, when several are available.

Careful examination of the relative merits of Guillaume's and Mahlke's methods leads to the conclusion that the fadenthermometer is not an improvement on the simple auxiliary stem of uniform bore, and that its apparent advantages are illusory. For work of moderate accuracy, either method is satisfactory, though Guillaume's method is usually simpler in practice. For work of the highest attainable accuracy, Guillaume's method is to be preferred.

GEOCHEMISTRY.—*Studies in ore deposition with special reference to the sulphides of iron.* E. T. ALLEN, Geophysical Laboratory. Communicated by A. L. Day.

*General Principles.*—The genesis of ores is essentially a chemical problem. It involves in each individual case the formation of one or more minerals. Barring those rare instances in which the geologist may be able to observe a mineral in the actual process of formation, the conditions of formation have to be inferred from the data obtained by field observation, supplemented by what chemical information is available. At the present time our chemical knowledge of minerals generally embraces something of their behavior toward certain reagents, and often little, if any, more. Accurate data on the genesis of most of them is still wanting. This will have to be accumulated by actually forming the minerals in the laboratory and studying the conditions in systematic fashion. The questions of first importance in mineral synthesis concern, of course, the condition of temperature and pressure and the composition of the systems in which the minerals have formed.

By laboratory study, certain limits to these conditions may be set, outside of which the mineral can not exist, though in general the limits will be wide. Thus if we learn that a certain mineral can not exist above 450°, we know only that the mineral in nature must have formed somewhere between this point and the lowest temperature which prevails in the earth's crust. It is quite probable that we shall be able in many cases to narrow down these temperature limits by the study of paragenesis. Thus if we could determine the temperature limits of two different minerals which, on account of their intergrowth or otherwise, could be shown to have formed at the same time, it would be certain in that particular instance that the minerals formed inside the temperature range which is common to both. Thus far, we have been able to set these temperature limits for comparatively few minerals, chiefly those which are capable of existing in more than one crystal form. Here the temperature is often the most important condition determining *which* crystal form shall appear.

and this characteristic of the mineral may be taken as an index of the temperature which prevailed in its genesis. In a similar way, the composition of original solutions has to a slight extent been determined, since it has been observed that crystal form is sometimes determined by the composition of the solution in which the crystal grew. For the determination of pressure limits, there is at present no method.

In drawing inferences regarding the genesis of natural minerals from experiments in mineral synthesis, one must of course be constantly on guard lest he mistake secondary for essential conditions. It is therefore necessary for the chemist who works in this field to keep in constant touch with the geologists.

*The Sulphides of Iron.*—In this paper we shall consider the application of some of the above principles to the mineral sulphides of iron which form one of the most important classes of the sulphide ores. The frequent association of these minerals, pyrite, marcasite and pyrrhotite, with other valuable minerals of the sulphide group would indicate that the knowledge of the conditions of the genesis of the former might be applied to the latter as well. Also the association of the different sulphides of iron with one another have suggested several interesting problems of more particular nature which will here be considered.

*Pyrite and Marcasite.*—Pyrite and marcasite, the disulphides of iron, often occur in such geological formations as to lead to the belief that they were precipitated from cold surface solutions. A typical case of this character is the deposit in the Mississippi Valley. Geologists have reasoned that these and similar deposits have been precipitated from sulphate solutions because surface waters have frequently been observed by them to carry ferrous and ferric sulphates which were formed by the oxidation of older deposits of pyrite or marcasite thru the action of atmospheric influences:

$$FeS_2 + 7 \text{ O} + H_2O = FeSO_4 + H_2SO_4.$$
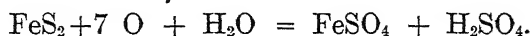
Observation has gone a step farther. Recent pyrite has been observed in wooden conduits, and on the twigs of trees which have fallen into hot springs, and the fact that the same mineral

occurs on coal and sometimes associated with asphalt has led to the conclusion that the ferrous sulphate has been reduced in some way by carbonaceous matter to $FeS_2$. A disulphide obviously could not be formed by simple reduction, but a more complicated process in which ferrous carbonate would be one of the products may be conceived of. The following equation in a very imperfect way conveys this notion:

$$7\,C + 4\,FeSO_4 = 2\,FeS_2 + 2\,FeCO_3 + 5\,CO_2$$

Omitting details, it may be stated that experiments which have been directed toward the formation of pyrite and marcasite thru the agency of carbonaceous matter have been entirely without result. A possibility of synthesis is suggested by the fact that pyrite and marcasite are very commonly associated with other sulphides of a simpler nature, such as sphalerite and galena which are directly precipitated by hydrogen sulphide. Experiments have in fact shown that both pyrite and marcasite may be obtained by the action of hydrogen sulphide on ferric sulphate solutions. It is well-known that ferric sulphate is directly reduced by hydrogen sulphide to ferrous sulphate with a simultaneous precipitation of sulphur, but it had not previously been noticed that the further action of hydrogen sulphide and sulphur on ferrous sulphate slowly gives rise to a dark precipitate having the composition $FeS_2$. This reaction, which we may represent by the equation

$$FeSO_4 + H_2S + S = FeS_2 + H_2SO_4$$

takes place even at ordinary temperature, though quite slowly. A microscopic examination of product proves that it is distinctly crystalline, tho the crystals are minute. If the reaction is allowed to go on at a sufficiently high temperature in a sealed glass tube, say 200° C., the crystals grow large enough to measure, and it has been found that they are partly marcasite—a mineral which has not previously been made artificially. A method was devised by H. N. Stokes for the analysis of mixtures of natural pyrite and marcasite which we have used to great advantage on the laboratory products. It consists in the oxidation of the

sulphides by a dilute solution of ferric sulphate. The products of the reaction are ferrous sulphate, sulphur, and sulphuric acid for both minerals, but the relative quantities of the products are decidedly different. Only 14 per cent of the sulphur in marcasite is thus oxidized to sulphuric acid, the rest being precipitated as free sulphur, while 56 per cent of the sulphur in pyrite is oxidized. It is thus possible to determine in any mixture of the two sulphides the percentage of each. As was stated above, the action of hydrogen sulphide on a mixture of ferrous sulphate and sulphur gives in general a mixture of both pyrite and marcasite, and the application of Stokes' method has proved that there are two essential conditions which determine the proportions of the two; these are temperature and acidity. The higher the temperature during the reaction, the greater is the percentage of pyrite obtained. It is also true that the lower the acidity of the solution, the greater is the percentage of pyrite formed, until, when the solution becomes neutral or alkaline, the product is practically all pyrite. The equation on p. 172 shows that it is not possible to maintain the solution neutral when hydrogen sulphide acts on ferrous sulphate and sulphur, for sulphuric acid is one of the products, but if we substitute suspended ferric hydroxide for the ferrous salt, the solution remains neutral, if we waive the question of the weakly acid nature of hydrogen sulphide itself. Another way in which we can command the same essential conditions is to heat pyrrhotite or ferrous sulphide with free sulphur and a water solution of hydrogen sulphide which contains a very little sodium bicarbonate. This solution dissolves and carries over the sulphur to the pyrrhotite, thus forming $FeS_2$ in a practically neutral solution and the result is pyrite.

An alkaline solution of sodium polysulphide precipitates from a ferrous salt an amorphous mixture of ferrous sulphide and sulphur, but these combine slowly under the influence of heat, and probably, even at the ordinary temperature, with the formation of pyrite.[1] These data enable us to draw some important

[1] At the lower temperatures (100°) amorphous disulphide appears to be the first product.

conclusions relating to the formation of these minerals in nature. (1) We know that the mineral marcasite can be formed by the action of hydrogen sulphide on ferric sulphate solutions, or, what comes to the same thing, a solution containing ferrous sulphate[2] and hydrogen sulphide to which the air finds some access. If the solution contains as much as 1 per cent of free sulphuric acid and the temperature is not above 100°, the product is all marcasite. It is also not improbable that pure marcasite can form at a higher temperature if the solution is still more acid. Now, these conditions agree strikingly with what we find about the genesis of marcasite from field study. It is always a surface mineral, presumably formed from surface solutions at *low* temperatures. It is also a matter of common knowledge that such solutions when they contain iron usually carry it in the form of sulphate, together with sulphuric acid, since they result from the oxidation of an older body of pyrite or marcasite. (2) We know that pyrite forms from solutions which are neutral or alkaline by the action of alkaline polysulphides on ferrous salts and by the action of hydrogen sulphide on ferric hydroxide. Both reactions are essentially the union of ferrous sulphide and sulphur in a neutral or alkaline medium. Coming again to the deductions from field observation, it is found that pyrite is always deposited by hot waters instead of marcasite, and that deep veins which formed under comparatively high temperatures also contain pyrite, never marcasite. Now, hot terrestrial waters are practically always alkaline, not only because silicates are hydrolized by hot waters with the necessary formation of an alkaline solution,[3] but because if a strong acid were allowed to act on rocks at the high temperatures which prevail in the depths of the earth's crust, chemical action would soon neutralize it by the decomposition of carbonates, silicates, etc. (3) Pyrite and marcasite form together when hydrogen sulphide acts on ferric sulphate unless the percentage of free acid and the temperature are

[2] It is not essential to use the *sulphate;* any other ferrous salt will suffice.

[3] This, of course, postulates the presence of some alkali or alkaline earth metal in the rocks, but some of these metals are practically always present.

sufficiently low. The quantity of free sulphuric acid must- be about 1 per cent at 100° to insure the formation of marcasite free from pyrite, while at 300° it must be considerably more, if indeed it is possible to get a product free from pyrite at that temperature. Pyrite and marcasite are very commonly found together in nature, often in the same hand specimen and sometimes inter-grown. Altho in some cases the two minerals probably belong to different periods of deposition, it seems entirely probable, in view of the laboratory results, that in other cases they are contemporaneous.

*The Relation of Marcasite to Pyrite.*—When marcasite is heated to a temperature of 450° C., under conditions which preclude oxidation, it changes to pyrite. Not only does its color become yellower and its density higher (the density of marcasite is 4.889, that of pyrite 5.02), but its behavior with a ferric sulphate solution proves conclusively that it has become pure pyrite; for while at the start the ferric sulphate oxidized only 14 per cent of the sulphur of all the marcasite it decomposed, now it oxidizes 56 per cent. In a comparatively simple way, it can be shown that heat is set free during this change, which proves, of course, that marcasite possesses more energy than pyrite. Pyrite cannot be changed directly into marcasite, *i.e.*, the change is irreversible and marcasite is what is called a monotropic form. The question of the chemical constitution of the two forms will not be discussed here, except that it may be remarked that they *appear* to be polymorphic forms in which the difference is one of crystalline structure rather than of a chemical nature. More important for the problems of ore deposition is the significance of the temperature at which the change occurs. It goes on at 450° very slowly and could not be detected at 400° in a period of four hours. It will be observed, therefore, that marcasite cannot have formed in nature above 450° and any minerals which can be shown to have been precipitated at the same time with marcasite are subject of course to the same limitation. Pressure can not be invoked to qualify this statement, for a pressure of several thousand atmospheres was found not to accelerate the change. We may also conclude that a paramorph of pyrite after marcasite would show that the

original crystal had been subjected to a temperature the lower limit of which lies somewhere between 350° and 450°, because at 300° marcasite crystals were found not to be changed to pyrite, either by acid or alkaline solutions.

*Pyrrhotite* can be readily formed by the decomposition of pyrite in hydrogen sulphide at temperatures above 575°. The higher the temperature is carried, the more sulphur is lost, and a product formed at high temperatures, say at 800° to 1100° C., takes up more sulphur when heated in hydrogen sulphide below that temperature. Although it is somewhat aside from the main purpose, of this article, viz., to discuss certain problems of ore deposition, it may nevertheless be of sufficient interest to remark in regard to the mooted question of the true chemical formula for pyrrhotite, that this mineral is really variable in composition, at the same time preserving its homogeneity; in other words, ferrous sulphide can dissolve a quantity of sulphur depending on the temperature like any other solubility. At 600° the maximum quantity dissolved is 6.0 per cent. We may if we please represent such a solid solution by the formula $(FeS)S_x$.

Under the experimental conditions thus far tested (*i.e.*, heating pyrrhotite in dry $H_2S$) a solution containing only about 6.0 per cent can be obtained after which further sulphur changes pyrrhotite into pyrite. The pyrrhotite of nature doubtless formed from solution, yet it is remarkable that the highest percentages of sulphur in the natural mineral range in the neighborhood of 6 per cent dissolved sulphur (*i.e.*, about 40 per cent of total sulphur).

Geological observation leads to the conclusion that vein forming solutions, doubtless polysulphides, change pyrrhotite to pyrite, and phenomena are observed about contacts which lead to the belief that the reverse action, the decomposition of pyrite into pyrrhotite and sulphur, occurs. In the neighborhood of contact intrusive masses, where the sulphides of iron occur, pyrrhotite is found close to the contact where the temperature was highest and pyrite in the colder zones. It is commonly held by geologists that in nature pyrrhotite was formed from the same solutions as silicates like olivine and augite. The experimental difficulties are at present too great to attack this question.

In conclusion, the author wishes to express his indebtedness to Drs. J. L. Crenshaw and John Johnston, and Mr. Esper Larsen, in collaboration with whom the experimental data for this article were worked out; and to Dr. F. L. Ransome and W. H. Emmons, and especially to W. Lindgren, for geological data.

MINERALOGY.—*A study of the rutile group.* WALDEMAR T. SCHALLER. To appear in a bulletin, "Mineralogical Notes, Series II." of the U. S. Geological Survey.

A theoretical study is made of the minerals comprising the rutile group—rutile, cassiterite, mossite, tapiolite, nigrine, iserite, ainalite, ilmenorutile and strüverite. It is shown that they are all either members or mixtures of members of a group of "primary compounds", of which there are six chief ones, namely, ferrous columbate $Fe(CbO_3)_2$, ferrous tantalate $Fe(TaO_3)_2$, ferrous titanate $Fe(TiO_3)$, titanyl titanate $(TiO)(TiO_3)$, stannyl stannate $(SnO)(SnO_3)$ and ferrous stannate $Fe(SnO_3)$. A study of all the available analyses of these minerals proves the validity of the assumptions made and it is concluded that of these minerals only three, tapiolite, rutile and cassiterite, are definite species. Ilmenorutile (and strüverite from Italy) is an isomorphous mixture of compounds, in which iron, tantalum, columbium, and titanium are present in quantity; strüverite from South Dakota is a columbic ilmenorutile; mossite is a columbic tapiolite; nigrine and iserite are ferrous rutiles; ainalite is tantalic cassiterite; and the various cassiterites from Mexico are ferrous cassiterites, arsenical cassiterites, etc.

# ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

TERRESTRIAL MAGNETISM.—*Magnetic chart errors and secular changes in the Indian Ocean.* L. A. BAUER and W. J. PETERS. Journal of Terrestrial Magnetism and Atmospheric Electricity. 1911.

This article gives a summary of the magnetic declinations together with geographic positions as determined on the *Carnegie* during her recent cruise from Cape Town to Colombo, Ceylon, and thence to Mauritius, in April to August, 1911. The tables of values are supplemented by the corresponding values scaled from a British Admiralty chart of 1907, the German chart of 1910, and the United States Hydrographic Office chart of 1910, these values being referred approximately to the time of observation by secular changes as indicated on the respective charts. The differences between the *Carnegie* values and those of the various charts are given. With the exception of a few values during the first part of the cruise from Cape Town the chart errors are always negative, that is to say, the chart values are too low and hence a value of west declination scaled from any of the charts mentioned must be increased to make it correspond with that of the *Carnegie*. The errors are unusually large, running up at times to 4°, and for one of the charts is even as much as 6°. These chart errors, while partly due to the defective spacing of the lines of equal magnetic declination, are to be referred chiefly to erroneous secular changes applied to the previous data on which the charts depend.

From a comparison of the *Carnegie* values with those of the German Antarctic ship, the *Gauss*, made in 1903 by Dr. Bidlingmaier, secular variation data may be obtained. The following values for secular change result from the consideration of means at points common to the two vessels. For the region of the mean south latitude 37° 29′ and east

longitude 25° 52′, the average annual change is −10′.9; for the region of the mean south latitude 35° 16′ and east longitude 74° 46′ the mean average annual change is +13′.2; and for the region of the mean south latitude 25° 17′ and east longitude 60° 35′ the average annual change is +5′.4. The mean secular changes corresponding, as taken from the British Admiralty chart and the United States Hydrographic Office chart above referred to, are respectively −2′.5, +2′.5, −2′.2. The plus sign attached to the secular change indicates that west declination is at present increasing for the locality, the minus sign meaning of course the reverse. It will be noticed that the charts give considerably smaller values, and in the last case values of reversed sign. The large changes and the rapid variation with geographic position are to be especially noted.

The errors of the charts in magnetic inclination reach a maximum of about 3 degrees and in horizontal intensity of a unit in the second decimal C.G.S. J. A. Fleming.

TERRESTRIAL MAGNETISM.—*Comparisons of magnetic observatory standards by the Carnegie Institution of Washington.* J. A. Fleming. No. 1. Journal of Terrestrial Magnetism and Atmospheric Electricity, **16**: 61–84, pl. IV. 1911. No. 2. To appear in same Journal.

A summary is given of the intercomparison observations made at various magnetic observatories throughout the world by the Department of Terrestrial Magnetism for March, 1911. The accuracy striven for is such that will be sufficient for ordinary magnetic survey purposes and for this reason the intercomparisons are made with the usual field instruments and methods and in the course of regular field work as opportunity permits. Detailed descriptions of the various instruments used and their constants are given. The methods of observation followed are according to the usual scheme of work at land stations, no elaboration except in number being attempted.

The corrections of each instrument used are all referred to the provisional international magnetic standards of the Department.[1] These corrections are determined by observations at Washington, which are made practically under the same conditions as prevail in the field and involve simultaneous observations with both the standard instrument

[1] Bauer, L. A., Preliminary note on International Magnetic Standard. Terr. Mag., **12**: 161-165. 1907.

and the one being compared, as well as the interchange of instruments and observers between the stations, in order that there may be no uncertainty from ignorance of the precise station difference, if any, due to local attraction, either natural or an unsuspected artificial one. Specimens of such intercomparisons are given in detail.

The intercomparisons reported upon were made at the following observatories: Sitka, Alaska; Potsdam, Germany; Kew, England; Falmouth, England; Pola, Austria; Toronto, Canada; Tiflis, Russia in Europe; Tashkent, Russia in Asia; Baldwin, United States; Cheltenham, United States; Zi-ka-wei, China; Dehra Dun, India; Helwan, Egypt; Havana, Cuba; Hongkong, China; Honolulu, Hawaii; Vieques, Porto Rico; Alibag, India; Apia, Samoa; Pilar, Argentine Republic; Sydney and Melbourne, Australia; Christchurch, New Zealand. By means of the results obtained by the Department at Kew and Potsdam further intercomparisons of observatory standards are obtained indirectly through the recent work of Dubinsky and Kühl at additional observatories as follows: Upsala, Sweden; Pavlovsk and Katharinenburg, Russia in Europe; Rude Skov, Denmark; Irkutsk, Russia in Asia; de Bilt, Netherlands; and Val Joyeux, France. The indirect comparisons are of especially great interest because of the conception given by them of the relative precision obtainable with entirely different types of instruments and independently determined constants.

From a summary of the comparisons it appears that the provisional standard adopted by the Department in declination is perhaps from 0.3 to 0.5 minute too high for east declination; in dip a corresponding amount too low in northerly inclination; and in horizontal intensity as much as 0.0001H to 0.0002H too high. The probable errors of the determinations are quite small, rarely exceeding 0.1 minute in declination, 0.3 minute in inclinations, and 0.00005H in horizontal intensity. The uncertainties involved in reductions for diurnal variation are much larger than the order of the probable errors but they may be considerably reduced by suitably selecting the time for observation.    J. A. F.

CHEMISTRY.—*Assay of Lactic Acid.* ELIAS ELVOVE, Hygienic Laboratory, Public Health and Marine Hospital Service. American Journal of Pharmacology, **83**: 14–19. 1911.

The United States Pharmacopœia specifies a lactic acid containing 75 per cent of true lactic acid and having a specific gravity of 1.206 at 25° C. An acid of this specific gravity should contain about 85 per cent of true lactic acid. This anomalous specification is due to the inaccuracy of the pharmacopœial method of estimation, which involves

direct titration of the boiling acid. In the procedure which is recommended, 50 cc. of normal sodium hydroxide are added to about 2 grams of the acid and the excess of alkali is titrated with normal sulphuric acid after the mixture has remained for thirty minutes at ordinary temperature, using phenolphthalein as indicator. E. E.

CHEMISTRY.—*Use of sulphur dioxide in checking strengths of volumetric solutions of iodine, alkali, and silver.* ELIAS ELVOVE, Hygienic Laboratory, Public Health and Marine Hospital Service. American Journal of Pharmacology, **83**: 19–23. 1911.

A scheme is outlined for basing the determination of the strengths of volumetric solutions on pure silver as a standard. The solutions would be prepared in the following order, each serving as a standard for the succeeding one: ammonium thiocyanate (standardised against pure silver), silver nitrate, hydrochloric acid, sodium hydroxide, oxalic acid, potassium permanganate, sodium thiosulphate, iodine. To control the standardisation, 25 cc. of the standard iodine solution is just decolorised by freshly prepared sulphur dioxide solution and the acid formed titrated with the standard sodium hydroxide solution. The total iodide in this neutralised solution could then be determined by adding excess of silver nitrate and titrating the excess of silver with standard ammonium thiocyanate, allowance being made for the pure potassium iodide used in preparing the iodine solution. E. E.

AGRICULTURAL CHEMISTRY.—*The toxic action of organic compounds as modified by fertilizer salts.* OSWALD SCHREINER and J. J. SKINNER. Science, **33**: 340. 1911.

The action of fertilizer salts in restraining the harmful influence of certain organic compounds was studied, as well as the effect of the compounds on absorption. The culture solutions comprised all possible ratios of the three principal fertilizer elements; phosphate, nitrate and potassium, varying in 10 per cent stages.

The various fertilizer salts acted differently in overcoming the respective harmful effects of the toxic compounds. The mainly phosphatic fertilizers were the most efficient in overcoming the cumarin effects; the mainly nitrogenous fertilizers in overcoming the vanillin effects; the mainly potassic in overcoming the quinone effects.

The cumarin depressed potash and nitrate removal from nutrient solution more than phosphate; the quinone, on the other hand, depressed phosphate and nitrate more than potash; the effect of vanillin was not determined in this regard. Dihydroxystearic acid, which, as previously

reported appears to act much as does vanillin, depressed phosphate and potash more than nitrate. In this respect again the influence of the various harmful substances is different.

The conclusion is drawn that different toxic substances produce definite effects in their action on plants and that the effects are modified differently by the different fertilizer salts.          M. X. SULLIVAN.

AGRICULTURAL CHEMISTRY.—*Biochemical factors in soil.* M. X. SULLIVAN. Science, 33: 543. 1911.

The soil is not an inert reservoir for plant food but is the seat of physical, chemical and vital actions, the biochemical factors being especially prominent. Numerous bodies which occur in soils and arise either in the metabolic activities of micro-organisms or are left in the soil after the decomposition of the plant and animal débris and perhaps offer also as a result of excretion from roots or from cell sloughing, play a considerable rôle in soil fertility. Some of these substances are harmful to plants, some beneficial. Fertilizers modify the physiological functions of the micro-organisms by bringing about suitable conditions for their development, in stimulating or retarding their digestion of inert bodies, and in furthering their enzymotic functions. Soils *per se* have oxidizing and catalyzing properties, while poor soils have these functions in a much lessened degree. Oxidation in subsoils, which are of much poorer productivity than surface soil, is usually slight. M. X. S.

PHARMACOLOGY.—*The pharmacopœial standard for desiccated thyroid glands.* REID HUNT and ATHERTON SEIDELL, Hygienic Laboratory, Public Health and Marine Hospital Service. American Journal of Pharmacy, 83: 407–411 (Sept.) 1911.

The parallelism between the iodine content and physiological activity of thryoid having been established, the authors call attention to the advantages of the method of Hunter (J. Biol. Chem., 7: 321–349. 1910), over the older Baumann method for the estimation of the organically combined iodine of thyroid, and suggest the incorporation of the Hunter method in the pharmacopoeial description of this drug. On the basis of the analysis of a large number of commercial desiccated thyroid samples, a standard iodine content of 0.2 per cent, with a maximum variation of 0.03 per cent above or below this figure is recommended. The limit for moisture is placed at 6 per cent, and that for ash at 5 per cent. Attention is called to the improbability of the claim that some recently prepared thyroid preparations contain thyroid iodine compound in a super active form.          A. S.

GEOLOGY.—*Geology and underground waters of northeastern Texas.* C. H. GORDON. Water-Supply Paper U. S. Geological Survey No. 276. Pp. 78, with maps, sections, and views. 1911.

Geologic formations that outcrop are (1) upper Cretaceous, (2) lower Tertiary, and (3) surficial deposits. In addition there are sands, silts, and clays of Pleistocene age and the flood-plain deposits of the present streams. Seven water-bearing horizons have been recognized, ranging in age from lower Cretaceous to Eocene.

Warping of the old Jurassic land-surface, which preceded and accompanied the deposition of later formations, gave the beds a gentle slope toward the Gulf of about 55 feet per mile.

Upon the upper Cretaceous beds in the south half of the district, without recognized stratigraphic break, lie sands, clays, and ferruginous sandstones belonging to the Eocene. At the beginning of the Eocene slight warping enlarged the Mississippi embayment, causing overlap of early Eocene beds upon the Cretaceous contemporaneous with marked change in fauna. During Eocene time near-shore or swampy conditions prevailed with an occasional submergence by the ocean. No Oligocene or Miocene deposits have been recognized. The Miocene was essentially a period of erosion, and if deposits of Oligocene age were laid down they were afterwards removed. During the Pliocene a mantle of sand, silt, and gravel was spread over the eroded surface, and was in turn eroded. Further Pleistocene deposition succeeded, giving rise to marine and fluviatile (Port Hudson formation) deposits. Erosion followed again, leaving the present flood plains and principal terraces.

H. D. McCASKEY.

GEOLOGY.—*Sewickley, Pa., Folio.* M. J. MUNN. Geologic Atlas of the United States, No. 176. Pp. 16, with maps and sections. U. S. Geological Survey. 1911.

Outcropping formations include the Allegheny, Conemaugh and Monongahela, of the Pennsylvanian series of the Carboniferous, and aggregate about 800 feet in thickness. Deep borings indicate 1200 feet of underlying Devonian and Carboniferous strata. The dip is south-southeast, at about 50 feet to the mile. Detailed study of the oil sands indicates greater folding in the older buried beds than in those above. It is suggested that the pre-Pottsville rocks were slightly folded during the early Pottsville uplift, developing lines of weakness followed by the post-Carboniferous folds. The Pleistocene is represented by four terrace formations, of which all but the oldest are outwash glacial gravels.

H. D. McCASKEY.

ECONOMIC GEOLOGY.—*Reconnaissance of the ore deposits of northern Yuma County, Arizona.* HOWLAND BANCROFT. Bulletin U. S. Geological Survey No. 451. Pp. 130, with maps, sections, and views. 1911.

The oldest rocks are granites and gneisses, probably Archaean, together with a group of highly altered sediments, with some igeneous rocks, cut by numerous intrusives of pre-Cambrian age. Some massive granite is provisionally assigned to the Mesozoic, and a series of volcanics with some sediments is regarded as Tertiary. Quaternary deposits are represented by conglomerate and basalt.

Mineralization took place in the pre-Cambrian, Mesozoic, and Tertiary periods.

Auriferous quartz veins and mineralized shear zones occur in the pre-Cambrian rocks. Another type of auriferous deposit, also of pre-Cambrian age, is represented by quartz siderite stringers in amphibolite schists and limestones. The largest deposits of copper and iron occur as irregular veins in shear zones in the amphibolitic and chloritic rocks and as replacements of limestone. Copper also occurs in shear zones and fissure veins in the Archaean gneiss and as fissure veins in the Tertiary lavas. Contact-metamorphic copper deposits are found in the zones of metamorphism between the limestones and Mesozoic intrusives.

A. H. BROOKS.

HYDROLOGY.—*The quality of the surface waters of Illinois.* W. D. COLLINS. Water-Supply Paper U. S. Geological Survey, No. 239. Pp. 94, 3 plates. 1910.

A coöperative investigation was conducted in 1906 and 1907 by the United States Geological Survey, the State Water Survey of Illinois, the engineering experiment station of the University of Illinois, and the State Geological Survey of Illinois for the study of the chemical composition of Illinois waters, their action on boilers, the purification of them for industrial and domestic use, and other similar problems. Stations were established on the principal rivers and reservoirs of the State at 26 places where daily samples of water were collected for one year for mineral analysis. The report discusses these analyses in relation to the sources of the mineral matter, its effect in economic uses of the water, and the cost methods of reducing its quantity. A noteworthy feature is the correlation of mineral content with stream discharge, typified by the computations of the relative components of Mississippi River at Chester. The physical and economic conditions that affect the quality of the waters are considered especially in reference to trades wastes.

The paper is concluded by tables of 700 analyses of water made during the study. It is a source of definite detailed information regarding the chemical composition of the surface waters of Illinois.    R. B. DOLE.

BOTANY.—*Inheritance of the "eye" in Vigna.*  W. J. SPILLMAN. American Naturalist, **45**: Sept.  1911.

Certain races of the cowpea (*Vigna unguiculata*) have the seed coat pigmented only in certain areas. In all such cases the pigmented area includes the region about the hilum and is called the eye. It varies widely in size and form.

Genetic studies of these races has demonstrated that there are two genetically distinct types of eye, both recessive. When the two types of eye are brought together in the same individual by proper cross-breeding, the resulting form of eye is that of the common eyed races of peas, in which there is a small pigmented area about the hilum. One type, without the other, gives a pigmented area covering something over half the surface of the seed; the other type alone gives a pigmented area about the hilum, the edges of the area being indistinct, fine dots of pigment extending into the unpigmented area and covering the micropilar end of the seed.

It is shown that four different hypotheses regarding the nature of the hereditary factors responsible for the eye are in accord with the genetic behavior of the characters in question.    W. J. S.

TECHNOLOGY.—*The diffusion of crude petroleum through fuller's earth, with notes on its geologic significance.*  J. ELLIOTT GILFIN and OSCAR E. BRANSKY. Bulletin U. S. Geological Survey No. 475. Pp. 50. 1911.

When a solution of benzene and a paraffin oil diffuses upward through a tube packed with fuller's earth, the benzene collects below and the paraffin oil above. When crude petroleum diffuses a fractionation occurs. The oil from the top of the tube possesses a lower specific gravity than that from the bottom. As the fractionation proceeds the range of specific gravity covered becomes smaller, indicating the production of mixtures which will finally pass through the earth unaltered. The amounts of unsaturated hydrocarbons and sulphur compounds in the fractions increase gradually from the lightest oils above to the heavier oils below.

Fuller's earth retains the unsaturated hydrocarbons and sulphur compounds in petroleum, thus exercising a selective action upon the oil.    H. D. McCASKEY.

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# JOURNAL

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# WASHINGTON ACADEMY OF SCIENCES

APPLIED MATHEMATICS.—*A criterion for best magnitudes in precise measurement.* MAYO DYER HERSEY, Bureau of Standards. Communicated by L. A. Fischer.

In the determination of a quantity $y$ from observations upon the independent quantities $x_1, x_2, \ldots x_n$ with which $y$ is connected by the relation

$$y = f(x_1, x_2, \ldots x_n)$$

there is frequently an option as to the order of magnitude which shall be assigned to the $x$'s before setting up apparatus. The problem of best magnitudes has long been recognized as a fundamental one in the theory of the precision of measurements, but available discussions are limited in their usefulness by the assumption of constant errors or proceed by a step-by-step calculation invented anew for each problem.[1]

The present analysis aims to formulate the reasoning once for all, setting up a general criterion from which special cases may be derived at will.

This is accomplished by the consideration of two functions $\phi$ and $\Theta$ beside the function $f$ characterizing the instrument or method. If in general $\Delta x$ denote an error in the observed quan-

[1] See, for example, Holman, "Precision of Measurements," pp. 100–119; Mellor, "Higher Mathematics for Students of Chemistry and Physics," pp. 531–540; Baum, "General Method for Determining Best Reading of an Instrument for Least Error," Phys. Rev. 1899: pp. 181–182.

tity $x$, then the function $\phi(x)$ is defined by the statement $\Delta x = \phi(x) \cdot \epsilon$, where the constant $\epsilon$ represents this error at some designated region of $x$, such as the zero point of a scale. On the other hand, if $\Delta y$ be the resultant error, then the function $\Theta(y)$ is defined by the understanding that it is $\Theta(y) \cdot \Delta y$ that we wish to make a minimum by our choice of best magnitudes for the $x$'s.

Granting that the resultant error is

$$\Delta y = \sum_{r=1}^{r=n} \frac{\partial y}{\partial x_r} \cdot \Delta x_r$$

it is seen that to make $\Theta(y) \cdot \Delta y$ a minimum, requires a minimum for

$$\Theta(f) \cdot \sum_{r=1}^{r=n} \frac{\partial}{\partial x_r} f(x_r) \cdot \phi(x_r) \cdot \epsilon_r$$

Differentiating by any particular $x$ such as $x_k$ will lead to the following condition for a maximum or minimum if we simplify the notation by omitting functional parentheses and by letting $p$ stand for $\partial f / \partial x$, and if we cast out as physically zero all derivatives of $\phi_r$ by $x_k$ except that of $\phi_k$ itself:

$$\frac{1}{\Theta} \frac{\partial \Theta}{\partial x_\kappa} \sum_{r=1}^{r=n} \epsilon_r \phi_r p_r + \epsilon_\kappa \frac{\partial \phi_\kappa}{\partial x_\kappa} p_\kappa + \sum_{r=1}^{r=n} \epsilon_r \phi_r \frac{\partial p_r}{\partial x_\kappa} = 0 \ldots \ldots (1)$$

This equation is the type for a series of $n$ simultaneous equations, the group constituting the criterion.

Those who are partial to the theory of probability will remark that we have taken for $\Delta y$ the actual error $\sum \frac{\partial y}{\partial x} \Delta x$ and not the (smaller) probable error $\left[ \sum \left( \frac{\partial y}{\partial x} \Delta x \right)^2 \right]^{\frac{1}{2}}$. The treatment of best magnitudes differs, however, from the greater part of the theory of errors in that it deals with the prevention and not with the computation of errors, and therefore must concern itself with the case when the errors do reinforce each other by pure addition. Nevertheless, the criterion for minimum probable error can be obtained from the other by replacing $\epsilon$, $\phi$, and $p$ by $\epsilon^2$, $\phi^2$, and $p^2$, and multiplying the first summation by 2. When there is but

one independent variable to consider, the distinction between actual and probable error vanishes.

Now from (1) by substituting $n = 2$, $x_1 = x$, $x_2 = z$, $p_1 = p$, $p_2 = q$, $\theta = 1/f$, and $\phi = 1$, we have the important special case of two independent variables with constant errors $\epsilon_x$ and $\epsilon_z$, a minimum fractional error $\Delta y/y$ being desired in the result. The criterion reduces to the single equation

$$(p - q) \cdot R = \left(\frac{\partial R}{\partial x} - \frac{\partial R}{\partial z}\right) \cdot f \quad \ldots\ldots\ldots\ldots (2)$$

where $R$ denotes $(p\epsilon_x + q\epsilon_z)$.

Finally for one independent variable, if we denote differentiation by primes and put $p = f'$, (1) becomes:

$$f' \; \phi \; \theta' + f' \; \phi' \; \theta + f'' \; \phi \; \theta = 0 \quad \ldots\ldots\ldots\ldots (3)$$

This breaks up into eight special cases upon assigning to $\theta$ the fundamental values 1 and $1/f$ while $\phi$ is restricted to 1 and $x$. The four most important in practice are the following:

1. When seeking a minimum absolute error, $\theta = 1$, consequently the criterion becomes:

$$f' \; \phi' + f'' \; \phi = 0 \quad \ldots\ldots\ldots\ldots\ldots (4)$$

2. When seeking a minimum fractional error $\theta = 1/f$.

$$\therefore \cdot \frac{\phi'}{\phi} = \frac{f'}{f} - \frac{f''}{f'} \quad \ldots\ldots\ldots\ldots\ldots (5)$$

3. When seeking minimum absolute error with constant error in $x$, $\theta = 1$ and $\phi = 1$, therefore

$$f'' = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

4. When seeking minimum fractional error with constant error in $x$, $\theta = 1/f$ and $\phi = 1$, so that

$$f' = \sqrt{f\,f''} \quad \ldots\ldots\ldots\ldots\ldots (7)$$

To fix in mind the meaning of the criterion, two examples, in themselves sufficiently simple to be verified by trial, may be added,—

I. Find best resistance for heating coil if power input $y = x \cdot z$ is deduced from readings of 15 $a$. ammeter with error $\epsilon_x$ and

150 $v$. voltmeter with error $\epsilon_z = 10\epsilon_x$. By (2), $p = \partial/\partial x(xz) = z$, while $q = x$; also $R = z\epsilon_x + x\epsilon_z$; $\partial R/\partial x = \epsilon_z$, $\partial R/\delta z = \epsilon_x$. Substituting and reducing,

$$\frac{z}{x} = \sqrt{\frac{\overline{\epsilon_z}}{\epsilon_x}} = 3.2 \text{ ohms.}$$

The condition for minimum probable error is $z/x = 4.6$ ohms.

II. Find best order of interference $x$ in determining relative wave-length $y = C/x$, if an error of observation of $1/100$ wave-length at zero path-difference becomes $\dfrac{1}{100}\left(1 + \dfrac{2x^2}{10^9}\right)$ on separating plates. Using (5), with $f' = \dfrac{-C}{x^2}$, $f'' = 2C/x^3$, and $\phi' = 4x/10^9$ gives at once the result $x = 22,000$.

In practice a distinction must be drawn between precision and accuracy.[2] If $\Delta x$ denote the precision of observation of $x$, the criterion leads to the best attainable precision in $y$; but if, from a knowledge of the reliability of his method, the investigator can go further and employ for $\Delta x$ an estimate of accuracy, the formulae lead to the conditions for best accuracy in $y$.

In either event, it is the aim of the criterion to afford rules of interest to the designer and experimenter rather than to the computer.

For their interest and criticism acknowledgment is gratefully made to President Woodward of the Carnegie Institution and to Drs. Burgess, Dorsey, Buckingham and Mr. L. A. Fischer of the Bureau of Standards.

RADIO-TELEGRAPHY.—*Notes from the U. S. Naval Wireless Telegraphic Laboratory.* L. W. Austin.

*1. Wave Length and Ground Absorption of Electrical Waves*

Since the early days of wireless telegraphy, the country lying to the north and north-east of Newport, Rhode Island, has been known to show a very large absorption for electrical waves.

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[2] In short, accuracy = (reliability of method) ± (precision of observation).

During the experiments in long distance radiotelegraphy[1] carried on at Brant Rock during the summer of 1910, the signals sent out by the Birmingham lying at Newport were measured at Brant Rock 45 miles away. The wave lengths used were 1000 meters and 3750 meters and the received signals were measured on a 15 ohm tellurium-constantan thermoelement.[2] One millimeter on the thermoelement galvanometer corresponded to a current of $263 \times 10^{-6}$ amperes.

The data of the observations are shown in the table. Under the column Calculated, are given the values taken from Table XVI of the paper cited. The difference between the calculated and observed values represents the excess of the ground absorption over that which would have been observed if the waves had passed over salt water.

BIRMINGHAM AT NEWPORT, RECEIVED AT BRANT ROCK

| WAVE LENGTH | SENDING ANTENNA CURRENT | DEFLECTION THERMOELE- MENT | RECEIVED ANTENNA CURRENT $10^{-6}$ AMP. | | ABSORPTION OF SIGNALS |
|---|---|---|---|---|---|
| | | | Observed | Calculated | |
| Meters | Amperes | Millimeters | | | per cent |
| 1000 | 28.7 | 16 0 | 1050 | 5400 | 95 |
| 3750 | 26.3 | 37.5 | 1600 | 1550 | 0 |

If we consider the strength of signal which is proportional to $I^2$, it will be found that 95 per cent of the energy was absorbed in the case of the 1000 meter wave, while in the case of the 3750 meter wave the ground absorption was not detectable, the observed signals being slightly stronger than the calculated values.

The experiment explains fully why with the short wave lengths ordinarily used, wireless communication has been so difficult over this region and indicates that where such difficulties are encountered longer wave lengths should probably be employed.

[1] Bureau of Standards Bulletin, 7: 315. 1911. Abstract, this Journal, 1: 82. 1911.

[2] See paper cited, p. 317.

## 2. Directive Action of the Marconi Bent Antenna at Clifden, Ireland

While the directive action of the Marconi bent antenna at short distances has been amply demonstrated by Marconi, Fleming and others, it has not seemed certain that this radiation asymmetry would not diminish as the distance increased so that at great distances the radiation distribution would be the same as that of an ordinary antenna.

Recently at the request of the wireless laboratory, the National Electric Signaling Company made telephone shunt measurements on the signals received at their Brant Rock station from the Marconi transatlantic station at Clifden. These indicated an average received energy in the day time of $5 \times 10^{-8}$ watts or in terms of current through 25 ohms as used in Table XVI of my paper already cited, $45 \times 10^{-6}$ amperes. I have been unable to obtain from the Marconi Company any data on the value of the antenna current at Clifden, but nevertheless some conclusions can be drawn from the information at hand. The distance from Clifden to Brant Rock is 2640 nautical miles. The height of the Clifden antenna considered as a flat top is approximately 200 feet, the effective receiving height of the Brant Rock umbrella antenna was found in the recent long distance experiments to be approximately 350 feet. The wave length of Clifden is a little more than 6000 meters and the total available power is 1100 h.p.[3]

In Tables XVI and XVII already mentioned, $h_1 = 200$ feet, $h_2 = 350$ feet, $d = 2500$ miles, in round numbers, and $I_r = 45 \times 10^{-6}$ amperes. We may calculate from the tables that the sending antenna current $I_s = 810$ amperes which is an enormous value. If the total antenna resistance is only 1 ohm it corresponds to 660 K.W. which is more than the whole 1100 h.p. would be able to transmit to the antenna. But this resistance is improbably small.

From this it must be concluded that unless the formula is grossly in error the bent Clifden antenna shows a decided directive effect even at this distance.

[3] Fleming, Principles of Electric Wave Telegraphy.

3. *A Table of Radiation Resistances for Various Wave Lengths and Antenna Heights*

The radiation theory of Hertz shows that the radiated energy of an oscillator may be represented by

$$E = \text{const. } h^2/\lambda^2 \cdot I^2 \dots\dots\dots\dots\dots\dots (1)$$

where $h$ is the length of the oscillator, $\lambda$ the wave length and $I$ the current at its center.

A TABLE OF ANTENNA RADIATION RESISTANCES

($h =$ height to center of capacity of conducting system)

| WAVE LENGTH $\lambda$ $h=$ | 40 FT. | 60 FT. | 80 FT. | 100 FT. | 120 FT. | 160 FT. |
|---|---|---|---|---|---|---|
| m | ohm | ohm | ohm | ohm | ohm | ohm |
| 200 | 6.0 | 13.4 | 24 0 | 37.0 | 54.0 | 95 0 |
| 300 | 2.7 | 6 0 | 10 6 | 16.5 | 23 8 | 42 4 |
| 400 | 1 5 | 3 4 | 6 0 | 9 3 | 13.4 | 23.8 |
| 600 | 0 66 | 1 5 | 2.7 | 4.1 | 6.0 | 10.6 |
| 800 | 0 37 | 0.84 | 1 5 | 2.3 | 3.4 | 6 0 |
| 1000 | 0 24 | 0 54 | 0 95 | 1 5 | 2.1 | 3.8 |
| 1200 | 0.17 | 0 37 | 0 66 | 1 03 | 1.5 | 2.6 |
| 1500 | 0 106 | 0.24 | 0 42 | 0 66 | 0.95 | 1.7 |
| 2000 | | 0.134 | 0 24 | 0 37 | 0.54 | 0.95 |
| 2500 | | | 0.15 | 0.24 | 0.34 | 0.61 |
| 3000 | | | 0 106 | 0.17 | 0.24 | 0 42 |
| 4000 | | | 0 060 | 0 093 | 0 134 | 0 24 |

| $\lambda$ $h=$ | 200 FT. | 250 FT. | 300 FT | 450 FT. | 600 FT. | 1200 FT. |
|---|---|---|---|---|---|---|
| m | ohm | ohm | ohm | ohm | ohm | ohm |
| 600 | 16 4 | 25 8 | 37 4 | 84.0 | 149 0 | |
| 800 | 9 2 | 14.5 | 21 0 | 47.0 | 84.0 | |
| 1000 | 6.0 | 9 3 | 13.5 | 30.0 | 54.0 | 215 0 |
| 1200 | 4.1 | 6 5 | 9.3 | 21.0 | 37.0 | 149.0 |
| 1500 | 2.6 | 4 1 | 6 0 | 13.4 | 24.0 | 95.0 |
| 2000 | 1.5 | 2 3 | 3.4 | 7.5 | 13.4 | 54 0 |
| 2500 | 0 95 | 1.49 | 2 2 | 4.8 | 8.6 | 34 0 |
| 3000 | 0 66 | 1.03 | 1 5 | 3.4 | 6.0 | 24 0 |
| 4000 | 0.37 | 0.58 | 0.84 | 1.9 | 3.4 | 13 4 |
| 5000 | 0 24 | 0.37 | 0.53 | 1 20 | 2.2 | 8.6 |
| 6000 | 0.16 | 0.26 | 0.37 | 0.84 | 1.49 | 6.0 |
| 7000 | 0 121 | 0.19 | 0.27 | 0.61 | 1 09 | 4.4 |

It has been shown by Ruedenberg[4] that for a flat top antenna the constant in the above formula is in round numbers 1600, or

$$E = 1600 \; h^2/\lambda^2 \cdot I^2 \ldots \ldots \ldots \ldots \ldots (2)$$

The term $1600 \; h^2/\lambda^2$ is commonly spoken of as the radiation resistance, inasmuch as it is a quantity which when multiplied by the square of the current gives the radiated energy.

The accuracy of equation (1) was verified in the experiments on long distance radio-telegraphy already cited. It has therefore seemed worth while to calculate a table of the radiation resistance for various heights and wave lengths.

ELECTRICITY.—*Methods for the measurement of the effective inductance of resistance coils.* F. W. GROVER and H. L. CURTIS. Communicated by E. B. ROSA. To appear in the Bulletin of the Bureau of Standards.

In the measurement of inductances which are associated with relatively high resistances, such as resistance coils, the multipliers of voltmeters and wattmeters and the like, the ordinary bridge methods using alternating current of suitable frequency are sufficiently sensitive, but they fail to give an accurate determination due to the fact that the inductance of each arm of the bridge is of the same magnitude as the inductance to be measured. The method which we have used to overcome this difficulty is to substitute for the unknown inductance, an inductance of approximately the same resistance, but of such a form that its inductance can be computed from its dimensions. From the changes in the bridge which it was necessary to make to restore a balance, the difference in the inductance of the two resistances was computed.

Three bridge methods were used. The first was Maxwell's method of comparing an inductance with a capacity; the second was Anderson's modification of the above; the third was the use of a variable inductance in one of the arms. These methods gave concordant results and the method to be chosen in any given case will largely depend upon the value of the resistance associated with the inductance which is being measured.

[4] R. Ruedenberg, Ann. d. Phys. 25: 446. 1908.

The standards used were in the form either of parallel wires or of circles. Only in the case of one-ohm coils was it practicable to use both forms. The agreement between the two forms was satisfactory as is shown by the following example. The difference in the computed values, after allowing for the inductance of the binding posts, was $128 \times 10^{-9}$ henry. The measured difference in the inductance was also $128 \times 10^{-9}$ henry. With standards having larger resistance different sizes and lengths of wire were sometimes used, as well as different distances apart. As an example, the 5000-ohm parallel wire standard was measured with the wires 2 cm. apart and again with them 10 cm. apart. The observed difference was 114 microhenrys. The computed difference when taking into account the distributed capacity between the wires was 110 microhenrys.

While in all cases the standards were adjusted to have nearly the same value of resistance as the coil to be measured, yet it was necessary to be able to vary the resistance thru a small range without varying the inductance. This was accomplished by two different devices. Steps of a tenth of an ohm were obtained by substituting for manganin links, copper links of the same size and form. A continuous variation of resistance from 00 to 0.1 ohm was obtained by means of a copper wire sliding in a tube of mercury. The change in inductance was very small in this case, but where small inductances were being measured, it was necessary to make a correction on this account.

The chief difficulty encountered was with coils of high resistance where the capacity between the wires appreciably affects the effective inductance. If $L$ is the computed inductance, $C$ the capacity between the wires and $R$ their resistance, then the effective inductance $L'$ is approximately given by the equation

$$L' = L - \tfrac{1}{3} \cdot CR^2.$$

In commercial resistance coils having resistances of 100 ohms or over the last term is usually the larger of the two, so that the effective inductance is negative. With coils greater than 1000 ohms the actual inductance is usually a negligible part of the effective inductance, so that the value of the effective inductance depends entirely upon the capacity and resistance. With parallel

wires the capacity not only depends upon the relative positions of the two wires, but upon their potential with respect to the earth.    The capacity as usually computed requires that the potential of one wire shall be as much above earth potential as the other is below earth potential.    To make sure that this requirement is fulfilled in practice, a special net work is arranged in which there are two indicating instruments, both of which must show zero current.    Altho somewhat complicated, this method gives satisfactory results in those cases where the capacity to earth is an important factor.

The methods here outlined have been found to give satisfactory results with resistances from 1 to 10,000 ohms.    With coils the resistance of which lies between 1 and 1000 ohms it was possible to measure the inductance with such accuracy that the error in the time constant (L/R) deduced from this measurement is not more than $10^{-9}$ second.    For coils with a resistance of more than 1000 ohms the corresponding limit is $10^{-8}$ second.

ORGANIC CHEMISTRY.—*A new bromine method for the determination of aromatic phenols. Its special application to thymol.* ATHERTON SEIDELL, Hygienic Laboratory.    Communicated by Walter Wyman.

A quantitative method for the determination of thymol being desired for use in experiments upon the solubility of this compound in various solvents, a search of the literature was made for a suitable method.    Those found were the Messinger and Vortmann iodine method (Ber. **23**: 2753.    1890), the various adaptations of the bromine method with Koppeschaar's bromate-bromide solution, and the diazonitraniline method of Riegler (Buletinal soc. sciinte. Bucuresci, **8**: 51.    1899).    Experiments with the first two of these gave unsatisfactory results and the sources of the errors were carefully investigated.    In the case of the iodine method an absolutely definite ratio of thymol to alkali was found to be required in order that accurate results might be obtained, therefore necessitating the knowledge of the amount of thymol before beginning the determination.    The difficulties which were encountered with the various adaptations of the bromine method appeared to be due to the too energetic action of the bromine in

aqueous solutions, or to its loss by volatilization during the determination. After many experiments these difficulties were surmounted and the following new method devised.

Briefly the principal involved is the conversion of the thymol to the dibrom compound, with formation of two molecules of hydrobromic acid, by addition of an excess of bromine vapor to an aqueous solution of the thymol in contact with a small amount of carbon bisulphide. After allowing to stand at ordinary temperature a short time, the excess of bromine is removed by means of potassium iodide and thiosulphate, and the free hydrobromic acid is then titrated after addition of excess of potassium iodate, by means of standard thiosulphate solution.

In practice the determination of thymol is made as follows. The weighed sample of 0.1 to 0.5 grams is placed in a 200 cc. glass stoppered bottle with 5 cc. $CS_2$ and about 100 cc. $H_2O$. Bromine vapor is then poured into the mixture until the color after thorough shaking shows that a considerable excess of Br is present. After one-half hour an excess of 10 per cent KI solution is added and the liberated iodine corresponding to the free bromine is titrated with 0.1 n thiosulphate, an excess of about 5 per cent $KIO_3$ solution is then added, the liberated iodine equivalent to the free HBr is titrated with 0.1 n thiosulphate. The difference between the two readings of thiosulphate gives the amount of HBr formed during the reaction, and calculating two molecules of HBr for each molecule of thymol the amount of the latter is directly obtained. A number of determinations gave the following results:

| SAMPLE OF THYMOL | CUBIC CENTIMETERS STANDARD THIOSULPHATE | | DIFFERENCE | CALCULATED PER CENT THYMOL |
| --- | --- | --- | --- | --- |
| | Free Br. | Free HBr. | | |
| 0 3124 | 25.4 | 63.6 | 38.2 | 99.9 |
| 0.2229 | 34.8 | 62 0 | 27.2 | 99.7 |
| 0.2838 | 26.9 | 61 65 | 34.75 | 100.0 |
| 0 3915 | 15.7 | 63.7 | 48.0 | 100.3 |
| 0.2833 | 19 5 | 54 15 | 34.65 | 100.0 |
| .0.3257 | 24 9 | 64.5 | 39.6 | 99.4 |
| 0 4298 | 30.7 | 83.5 | 52 8 | 100.3 |

(Factors for standard thiosulphate, Readings x 1.086 = 0.1 N exactly).

These results show that even with considerable variation in the amount of excess of bromine used, no appreciable effect upon the results is obtained.    The determinations can be easily made in less than an hour and no other standard solution than thiosulphate is required.    The effect of the carbon bisulphide is to prevent the too vigorous action of the bromine on the thymol; without its use high results are obtained unless only the slightest excess of Br is used and in that case the results are apt to be too low on account of using insufficient Br to complete the reaction.    The $CS_2$ appears therefore to act as a safety valve and assures accurate results even with considerable variation in the other conditions of the determination.    The $CS_2$ also has the advantage that since it is an excellent solvent for thymol it can be used to extract this compound from its mixtures or solutions, and then by adding water and excess of Br the determination readily made as above outlined.

There is little doubt that this method is of general applicability to practically all aromatic phenols for the determination of which various other bromine methods have so far been suggested.    It is my intention to ascertain the limits of the applicability of this method at an early date and publish the results in a more detailed paper  elsewhere.

MARINE    ENGINEERING.—*Thrust balancing in direct-connected, marine steam turbines*.    E. BUCKINGHAM, Bureau of Standards.    Communicated by C. W. Waidner.

It is desirable that in a direct-connected marine steam turbine, the steam thrust shall balance the propeller thrust so as to relieve the main thrust bearing, altho this bearing must be able to take up the full unbalanced thrust in either direction which may be thrown on it for short periods during maneuvering or as a result of accident.    If such a balance could be attained only at the expense of considerable sacrifices in other directions or only for one particular speed of the ship, it would not be worth much attention, and it appears from published designs that many builders attach little importance to close balancing.    It will be pointed out in this paper that a balance may be attained without

any important sacrifice of other qualities of the turbine, and furthermore that if the steam and propeller thrusts are balanced at full speed the balance will be maintained approximately at much lower speeds,—a matter of more consequence in naval than in commercial practice.

It may be regarded as a certainty that the standard direct-connected installation of the immediate future will have turbines of the mixed wheel-and-drum type driving independent shafts, each unit being complete in itself.

The operative advantages of the independent shaft system are obvious; and the superiority of the mixed drum-and-wheel construction is such that it is fast superseding the pure drum turbine, while the pure multicellular turbine has seldom been used and is now obsolete in marine practice.   The drum construction is more compact than the wheel construction and permits of the use of more blade rows in a prescribed length, beside reducing windage. It should be used at the low pressure (L.P.) end and should extend toward the high pressure (H.P.) end as far as the steam volume and blade lengths are great enough that ample radial clearances can be used without serious leakage losses.   Above this point, the use of impulse-wheel stages contracts the leakage ring to the diameter of a shaft bushing and permits of unlimited radial clearances.   At the H.P. end the use of impulse stages with variable partial admission offers several well recognized advantages.   The following remarks, therefore, refer only to the mixed turbine, and they relate to the problem of deciding where the drum should begin.

With a single rotor and unidirectional flow aft, the steam thrust, due in the main to the difference of pressure on the ends of the drum, is available for balancing the propeller thrust.   From the speed-power curve of the hull the thrust may be found for the assigned speed at which a balance is desired; and from the estimated propulsive coefficient the shaft horse-power of the turbine computed.   If the terminal conditions of pressure, superheat, and vacuum are specified, together with the revolutions per minute, we may then, from the data on efficiency obtained by experiment on stages of the general style to be used,

make a sketch design and determine approximately the form of the curve of pressure distribution thru the turbine at the given power. It is then easy, if the diameters of drum and shaft have been fixed, to decide what pressure should act on the H.P. end of the drum in order that steam and propeller thrusts shall be balanced. The pressure drop to this point is to be taken upon wheels, and the remainder on the drum. If the data are good and the computations correctly made, the rotor and shaft will float at some speed close to that assumed.

In general, it will be found that the length of the drum computed in this way is much less than would seem advisable if the question of thrust-balancing were not considered— there will be too many wheel stages and the efficiency will suffer because not enough blade-rows can be got into the prescribed length. With a turbine of large diameter, a satisfactory compromise is impossible. The writer has seen one design of turbines for a battleship, in which the drum was long enough that at full power the steam thrust was about 60 per cent greater than the propeller thrust, while the drum was still much shorter than was desirable from the point of view of economy.

The obvious escape from the conflict of requirements is the adoption of some double-flow scheme. This complication may not be at all worth while in small machines, but for large powers when a division of the turbine into two lighter parts is advantageous in itself, the double-flow arrangement offers a simple solution of the difficulty. Let the H.P. rotor consist of the wheel stages and the first drum while the L.P. rotor consists of a second drum—combined of course with the backing turbine. The steam flows aft thru the H.P. turbine, thence to the after end of the L. P. drum, and exhausts at the forward end of the L.P. casing. The two drums thus exert opposing thrusts and no matter what the pressure at the beginning of the H.P. drum, the intermediate pressure may be so chosen as to give the resultant steam thrust due to both drums any value we please. We are thus able to design the arrangement of stages as seems most desirable, regardless of thrust, using a long drum and only a few wheels. We then split the drum at the right point on the

pressure curve, turn the L.P. part end for end, and put in a separate casing. In this way we may get as close an approximation to exact balancing as is permitted by the accuracy of the data available in designing. The writer is not aware that this expedient has been used in marine turbine construction, but it is so obvious that it seems highly probable that it will be used soon.

The question next arises as to how nearly a balance attained for one speed will be preserved at other speeds, and it turns out that if the turbine is regulated in the ordinary way, a balance for full speed will be fairly maintained at much lower speeds. The amount of the residual thrust, forward or aft, at any speed, depends on various elements; and to compute it exactly, data corresponding to those already used for full speed and power must be available, but it will suffice here to treat a single case roughly.

Let us assume that at half speed the effective horse power needed to drive the ship is $\frac{1}{10}$ of that at full speed,—as it will be approximately. The propeller thrust is then $\frac{1}{5}$ of that at full speed, and if the thrust was balanced at full speed it will still be so if all the steam pressures are reduced to $\frac{1}{5}$ of their values at full power. We have, therefore, to ask how nearly this condition regarding the pressures is fulfilled.

The water rate of the turbine at half speed will probably be some 40 per cent greater than at full speed. Leaving out of account the change in propulsive efficiency, which is not great, we may conclude that at half speed the total amount of steam flowing thru the turbine will be about $1.4 \times \frac{1}{10}$ or $\frac{1}{7}$ nearly. How, then, is the pressure distribution in the turbine altered when the steam flow is cut down to $\frac{1}{7}$? The answer to this question is most opportune: if the steam flow is cut down, by throttling or by closing first stage nozzles, leaving all the subsequent passages thru the turbine unchanged in area, the pressure at every point in the turbine except the last few stages next the condenser remains very nearly proportional to the total flow of steam thru the turbine.

In our present example, therefore, the steam thrust will be reduced to $\frac{1}{7}$ while the propeller thrust is reduced to $\frac{1}{5}$, leaving an

unbalanced thrust forward of $\frac{1}{5}$—$\frac{1}{7}$, or $\frac{2}{35}$ of the whole propeller thrust at full power. A correction to be applied introduces an improvement. The condenser pressure while it falls somewhat, does not fall to $\frac{1}{7}$ of its value at full power, and as the condenser pressure is acting on the *forward* end of the L.P. rotor—in the case of the divided turbine—the steam thrust aft is in reality somewhat greater than $\frac{1}{7}$ and the balance closer than just computed.

The residual thrust can not, in any case, be computed very accurately, but it is quite evident that if the balance is good at full speed it can not be far off at half speed. The automatic readjustment of the pressure distribution which occurs upon a change in the amount of steam supplied, is favorable to preserving a balance existing before the change, and intermediate valves are superfluous in this respect as they have proved to be in others.

A more detailed treatment of this subject, with numerical illustrations, will be published elsewhere.

# ABSTRACTS

ASTRONOMY.—*Publications of the U. S. Naval Observatory*, second series, **6**: pp. LXXIX + 620, illustrated, 10 plates, 4°. 1911.

When the Naval Observatory was moved in 1893 from the old site to the new one on Georgetown Heights it was decided to discontinue the practice of issuing an annual volume, and to publish volumes only occasionally, these to contain, however, rather large pieces of work. Following this practice Volume VI includes all the Equatorial Observations made during the period 1893–1907, inclusive, with the 26-inch and 12-inch instruments, together with three appendices. The observations of Eros for parallax, however, have already been published in Volume III. (second series).

When the 26-inch was set up at the new site it was provided with a mounting and accessories furnished by Warner and Swasey, of the same general type as those of the large Lick and Yerkes telescopes. Of the old Clark instrument there remained only the object glass in its cell, the micrometers, the finders, and a few other small parts.

The walls of the 26-inch Equatorial building are of brick faced with rough white marble. In the plans for the new observatory, however, it was not intended that the dome of this instrument should have a masonry drum. It was proposed to erect steel uprights to carry the track for the dome, and have these uprights support a double wall of sheet metal which could be easily ventilated. As constructed the 26-inch telescope is very conveniently handled, and is stable. In these respects it excels, as far as can be learned, the large instruments made abroad.

As to some of the defects of the mounting, it may be noticed that although the driving clock is big and heavy, and furnishes plenty of power to carry the instrument, it has always had a troublesome periodic

error, the magnitude of which has been considerably reduced at the Observatory.

When the telescope is above the pier the thrust of the declination spindle is taken up by ball bearings, but when below the weight comes against a tool-steel collar evidently not intended to support it. It is clear that the designer did not quite comprehend how the instrument was to be used, since in the case of many objects in the south it is necessary to observe with the telescope under the pier.

When the 26-inch instrument left the makers the arrangement for illuminating the declination circle was not altogether satisfactory, and the circle could not be properly utilized. The illumination has been improved somewhat.

Three micrometers have been employed with the large Equatorial: Clark Micrometer I, Clark Micrometer II, and that by Warner and Swasey. The last has not been of much use. All these instruments have excellent screws, but were all constructed by men who were not quite familiar with the measurements that had to be made with them, and about the necessity for avoiding systematic errors, and they all have unnecessary defects.

In 1904 a bright field illumination was arranged by reflecting light from a small 2 candle power lamp to the inner surface of the objective by means of a prism within the telescope tube near the eye-end and just outside the cone of rays. A good illumination is furnished for magnifying powers up to about 550.

In the selection of work for the equatorial instruments the usual policy of the Naval Observatory has been followed, that observations should for the most part be for the improvement of the places of the Sun, Moon, and planets, and the fixed stars, and for the testing of the laws according to which the heavenly bodies are supposed to move. Usually, also, heavy pieces of observing are taken up which would not be cared for elsewhere, which it is necessary to extend over considerable periods, and in which it is important to secure continuity.

The plan of work, therefore, was to observe, (1) the satellites and the diameters of planets, (2) some of the interesting and difficult double stars, (3) minor planets and comets, and (4) occultations of stars by the Moon. The 26-inch has been devoted to the fainter and more difficult objects. Continuity in the observations of the satellites of Saturn, Uranus, and Neptune was considered important.

For about two years, 1898–1900, attempts were made to do spectroscopic work with the 26-inch Equatorial, in the way of determining

the motions of certain stars in the line of sight. However, on account of the strong colors existing in the flint and crown glasses of the objective no better results could be obtained than those given by a very much smaller instrument. It seemed proper, therefore, to discontinue spectroscopic investigations.

As to the observations included in this volume there are then: The satellites of Mars, measured with respect to the planet at five oppositions. These moons were discovered at the Naval Observatory, and their orbits were first determined there. They are interesting when any questions are considered relating to the evolution of the solar system, since they revolve about Mars in $7^h$ $39^m$ and $30^h$ $18^m$, respectively, while Mars itself rotates on its axis in $24^h$ $37^m$. Also, there are some very curious perturbations of the elements of these satellites, caused by the flattening of Mars.

The four bright moons of Jupiter were observed in pairs, according to the method of Otto Struve, during four oppositions. But since the bright moons can probably be measured more accurately in this way with the heliometer than with the equatorial the work was discontinued. Satellite VI, however, was observed with reference to fixed stars during the opposition of 1905–06, and has been measured regularly in that way since that time.

The satellites of Saturn were observed in pairs, using at first fifteen combinations, which number was afterwards reduced to nine. At one opposition, 1895, Hyperion was referred to Saturn.

The four moons of Uranus were referred directly to the planet, and the combination Titania-Oberon was also made. The satellite of Neptune was followed at every opposition except one.

These satellite measures are a proper extension of the work accomplished at the old Observatory site, which included rather elaborate monographs on the moons of Mars, Saturn, Uranus and Neptune, as well as the discovery of the very curious motion of the line of apsides of the orbit of Hyperion. The movement of the node and inclination of the orbit of Neptune's satellite, probably arising from a flattening of the planet, was pointed out by Mr. Marth as a result of the comparison of the Malta and Washington observations.

For the measures of diameters during the years 1900, 1901, and 1902 color cells were used to absorb the outstanding blue light of the secondary spectrum, these cells being placed in front of the eye-pieces.

A list was observed of 593 double stars. It was not intended to attempt any thing in the way of finding new doubles, but only to furnish needed measures of known pairs.

A list of 245 asteroids and 45 comets was observed.  Many asteroids were secured at more than one opposition.  A good many were found by means of photographic plates exposed for the purpose, and two were discovered at the Observatory.  For some time the asteroids discovered by the Rev. J. H. Metcalf of Taunton, Mass., were observed systematically, for the purpose of securing sufficient data so that orbits could be computed, and the asteroids found and identified at the following oppositions.  In the list are 20 of these bodies.

Considerable attention was given, also to the Watson asteroids. In general, it was intended to make observations of the minor planets only when measures had been lacking for some time.

Many of the observations contained in this volume have been printed in the *Astronomical Journal* and the *Astronomische Nachrichten*.  Also, a good many discussions of observations have appeared in the same journals.

There are three appendices to Volume VI which include: the Mass of Titan from Observations of Hyperion; the Orbits of Phobos and Deimos; the Orbit of Enceladus; a Determination of the Solar Parallax from Observations of Eros; Orbits of Asteroids and Comets; Reports on the Transit of Mercury of November 10, 1894; and a List of Publications issued by the United States Naval Observatory, 1845–1908.

The introduction contains convenient summaries, so that the material contained in the volume proper can be found easily.  ASAPH HALL.

TERRESTRIAL  MAGNETISM.—*Two new types of magnetometers made by the Department of Terrestrial Magnetism of the Carnegie Institution of Washington.*  J. A. FLEMING.  Journal of Terrestrial Magnetism and Atmospheric Electricity, **16**: 1–12, pls. I and II.  1911.

The instruments described are the result of the experience gained in the land operations of the Department of Terrestrial Magnetism, which has emphasized the great need of more portable and more compact instrumental outfits than were heretofore in general use, without any sacrifice in the degree of precision obtainable.  The controlling conditions in the designs and construction of the instruments described were: (a) portability; (b) compactness; (c) simplicity; (d) minimum of loose accessories; (e) readiness for immediate use; (f) the attainment of an absolute observational accuracy equal to that of the best field instruments now in use.

The new instruments are of two types.  The first is a theodolite mag-

netometer for astronomical work and the determination of magnetic declination and horizontal intensity; in general principles along usual lines but differing greatly in details. The second type is a universal magnetometer by means of which the three magnetic elements may be determined as well as the astronomical elements.

The magnet and suspension systems of both types are of like design. The magnets are true cylinders encased in gold-plated brass cylindrical sheaths to prevent rusting and to provide means of mounting the collimating optical system in order that the magnets may be left as perfect cylinders. The suspension systems are comparatively free from complex or intricate parts, all devices for clamping the phosphor-bronze ribbon used for suspension being such that they are not removable and may be manipulated with great ease. For the determination of the plane of no torsion there is attached permanently to the stirrup a graduated circle which may be brought into the focus of the magnetometer telescope (previously focused on a distant mark) by interposing an auxiliary lens; the graduations of the torsion circle are in divisions of two degrees so that the plane of detorsion may be rapidly determined within a fraction of a degree.

The theodolite magnetometer weighs with its case but 11 kilograms, which is about half that of the older forms of corresponding instrument used by this Department.

The universal magnetometer is completely assembled in one unit, comprising astronomical telescope and magnetometer for determination of magnetic declination and horizontal intensity, and dip circle for the determination of inclination and total intensity, and is therefore always ready for immediate use upon mounting on its tripod. The advantage of being able to proceed with the observations for any of the elements, without first assembling a number of parts, is evident and of peculiar value in taking advantage of every available opportunity for work. The weight of this instrument without its packing case is $7\frac{1}{4}$ kilograms; the case weighs about 6 kilograms so that the total weight is only about 13 kilograms.

The results of comparisons with the new instruments, both at the office and under field conditions, have clearly shown that the degree of precision obtainable with them is of the same order as that to be had by types of standard instruments previously used by the Department and other magnetic organizations, or, with care, an absolute accuracy of 0.5 minute in declination, 0.0002H in horizontal intensity, and about one-half minute in inclination.                                J. A. F.

BIOLOGICAL CHEMISTRY.—*Further experiments upon the determination of iodine in thyroid.* ATHERTON SEIDELL, Hygienic Laboratory, Public Health and Marine Hospital Service. Journal of Biological Chemistry, **10**: 95–108, Oct. 1911.

In this paper are presented the results of an extensive series of analyses made for the purpose of comparing the Hunter (J. Biol. Chem., **7**: 321–49. 1910), and Baumann methods for the determination of iodine in thyroid. The results demonstrate the superiority of the Hunter method, both as to reliability of results and simplicity of manipulation. Further evidence disproving the contention of Riggs that iodate is formed during the fusion of thyroid by the Baumann process[*] is presented. In practically all cases it was found that the older Baumann method gives only 80 to 90 per cent of the amount of iodine obtained by the Hunter method. The most probable cause of this difference is considered to be the loss of iodine which occurs during the acidification of the aqueous solution of the fused residue, during which there is an active evolution of $CO_2$ and since some of the nitrate of the fusion mixture is always reduced to nitrite, there must also be present free iodine, which is liberated by the nitrous acid generated from the nitrite upon acidification. This source of loss has been effectively overcome in the Hunter method, by converting the inorganic iodine to the iodic state, and at the same time removing the nitrite by means of sodium hypochlorite solution, before the aqueous solution is acidified. Duplicate determinations by the Hunter method are therefore quite satisfactory, while in the case of the Baumann method frequent irregularities of results which can only be explained on the assumption of a loss, are obtained.

Since it has been claimed by Koch (Proc. Am. Pharm. Assoc., **55**: 371. 1907), that the iodine content of desiccated sheep thyroids prepared at different seasons of the year was as much as three times as great in the winter as in the summer months, an experiment was made for the purpose of demonstrating the possible seasonal variation of the iodine content of dog thyroids. The glands from groups of dogs killed at intervals during more than a year at the Washington dog pound were analyzed for their iodine, but no regular variation with season could be detected. It appeared that the cause of this irregularity might be the individual variation of the dogs, and analyses were therefore made of the dried glands of individual dogs, with the result that very wide differences (0.036 to 0.271 per cent iodine) were found. From these results it was concluded that if there is a seasonal variation in the iodine content of the thyroid of dogs, the individual variations under ordinary conditions

are far too great to permit its detection by analyses of the collected glands from a reasonable number of dogs.

Thru the kindness of the firms of Armour and Company, and Parke, Davis and Company, samples of the several lots of their U. S. P. desiccated sheep thyroids manufactured during the past year and a half were sent to this laboratory for use in the work upon the pharmacopœial standards for this drug. The dates of the preparation of the several lots were given, and these together with the analytical results, furnished the necessary data upon the question of the seasonal variation of the iodine content. It was found that the results did not confirm the observation of Koch; there being the greatest possible irregularity with season. It cannot be claimed, however, that these results disprove Koch's claim since the glands from which the present lots of desiccated thyroid were prepared came from both sheep and lambs, and this fact is probably sufficient to explain the variation. It may be concluded, however, that unless Koch exercised particular care to have only the glands from sheep in his average lots, his results must have been due to an accidental regularity. · A. S.

PHARMACOLOGY —*Influence of diet on the thyroid gland.* REID HUNT, Hygienic Laboratory. Journal American Medical Association, **57**: 1032. 1911.

Indirect evidence had been obtained (Bulletin 69, Hygienic Laboratory) that certain diets have specific effects upon the thyroid gland of animals; in the present series of experiments direct evidence for this was obtained. After removal of the thyroid certain diets no longer produced certain characteristic effects; the thyroid glands themselves showed marked physiological effects resulting from the diets. Oatmeal and liver were found to increase the activity of the glands; milk and eggs decreased it. The latter diet markedly increased the reproductive activity of the animals (mice and rats) used in the experiments. R. H.

GEOLOGY.—*Foxburg-Clarion, Pa., Folio.* E. W. SHAW and M. J. MUNN. Geologic Atlas of the United States, No. 178. Pp. 17, with maps and sections. U. S. Geological Survey. 1911. *Coal, oil and gas of Foxburg Quadrangle, Pa.* E. W. SHAW and M. J. MUNN. Bulletin U. S. Geological Survey No. 454. Pp. 85, with maps and sections. 1911.

Outcropping rocks, aside from the Quaternary stream deposits, belong to the Cuyahoga, Burgoon, Allegheny, and Conemaugh forma-

tions of the Carboniferous.  The lowest rock (Cuyahoga shale) appears in the bottom of the Allegheny Gorge; the Burgoon and Pottsville sandstones outcrop along the valley sides, and the Allegheny and Conemaugh, which consist of shale, sandstone, and limestone, with interbedded coal and clay, appear higher in the hills.  The dip is gently to the south with modification by low folds.

The principal streams are Allegheny and Clarion rivers and Redbank Creek, and along these a much discussed system of high terraces and abandoned valleys is well developed.

The coal beds lie mainly in the Allegheny formation.  The lower and upper Clarion, lower Kittanning, and upper Freeport coals are the most important.  Oil and gas in great quantities have been found in sandstones of the upper part of the Devonian and lower part of the Carboniferous.                                    E. W. S.

GEOLOGY.—*Geology and mineral resources of the St. Louis Quadrangle, Mo.-Ill.*  N. M. FENNEMAN.  Bulletin U. S. Geological Survey No. 438.  Pp. 73, with maps, sections, and views.  1911.

The hard rocks outcropping in the St. Louis quadrangle are all of Carboniferous age and include the Osage, Merrimac, and Chester (?) groups of the Mississippian, all of which have been further subdivided, and the Pennsylvanian coal measures.  Older rocks, including the Kinderhook formation (Mississippian) and part of the upper, Ordovician have been reached by drilling.  The Paleozoic rocks are unconformably overlain by Lafayette gravel of Tertiary age.  The Pleistocene is represented by the Kansan and Illinoian drifts, by loess, and by glacial outwash of the Wisconsin stage.  The recent deposits of the region include terrace gravels and the alluvial filling of river valleys.

The Paleozoic strata dip in general north-northeasterly, the fall being from 50 to 60 feet to the mile.                          A. H. BROOKS.

## PROGRAMS AND ANNOUNCEMENTS

### PHILOSOPHICAL SOCIETY

699th Meeting, November 11, 1911, Cosmos Club at 8.15.

A. J. LOTKA: *Evolutions in discontinuous systems.*

ELECTRICITY.—*A determination of the international ampere in absolute measure.*  E. B. Rosa, N. E. Dorsey and J. M. Miller, Bureau of Standards.

The absolute unit of current in the electromagnetic system is defined in terms of the magnetic field which it produces.  Hence we can measure current in absolute units by measuring the magnetic field due to the current, or by measuring the ratio between this field and some other field which is measurable, as, for example, the earth's magnetic field.  The comparison may be made by means of the tangent galvanometer, and is often called the tangent galvanometer method.

Or, we can calculate the force of attraction between circuits carrying electrical currents, and determine the current by measuring the forces of attraction experimentally; this is called the electrodynamometer or current balance method.  The potential energy of two circuits relative to one another is equal to $I_1 I_2 M$ where $I_1$ and $I_2$ are the strengths of the currents flowing in the two circuits and $M$ is the flux of magnetic force through one circuit produced by a unit current in the other, that is, the mutual inductance.  The force or torque between the two circuits tending to produce a displacement is measured by the rate of change of the potential energy.  If the currents are constant, we have to consider, therefore, only the rate of change of the mutual inductance.  If a particular displacement be represented by a change $dx$ in the variable $x$, and the current is the same in the two circuits, the force $F = I^2 \dfrac{\partial M}{\partial x} = KI^2$, in which $M$ has the dimensions of a line; hence $\dfrac{\partial M}{\partial x} = K$ is of zero dimensions, and is a function

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only of ratios of the dimensions of the electrical circuit. To measure the current $I$, the force $F$ must be measured and $K$ must be determined. As to the method of measuring $F$ and determining $K$, the various types of instruments differ.

The force or torque may be balanced by

(a) The elastic deformation of a wire or fiber.
(b) The gravitational attraction of the earth.

Then the torque or force must in turn be evaluated in absolute units.

$K$ may be determined in three ways

(c) by measurements of the separate dimensions of the instrument.

(d) by comparisons of the instrument with some other instrument, the dimensions of which can better be measured.

(e) by measurements of the ratios of the dimensions which enter into $K$.

The accuracy attainable with the instrument depends upon the possible accuracy of these determinations.

The method (a) requires a direct determination of the force of restitution of the deformed body (generally a fiber) as it was used in the electrical measurements. The elastic after-effects shown by all material bodies introduce formidable difficulties.

The method (b) requires the measurement of a force by weighing, and the absolute value of the acceleration of gravity. The first is capable of extreme precision. An accurate determination of the second is very difficult, but results obtained with this method at different times and places can be very accurately compared by relative determinations of the acceleration of gravity and may be corrected at any time when the absolute value is determined to a higher degree of accuracy.

The determination of the constant $K$ by the method given in (c) requires that the geometrical form of the apparatus be simple and the dimensions relatively large. Thus, the use of single layer coils is necessitated in general. The forces of attraction are usually small and can, therefore, be measured accurately only with difficulty. Furthermore, the constant is determined once for all and must be assumed to remain constant.

The method (d) allows the use of multiple layer coils and some other features which tend to give a high sensibility in non-absolute instru-

ments.  The limitations of simplicity of form are, however, imposed upon a second apparatus with which the instrument itself is compared.

The method (c) allows the use of multiple layer coils and the resulting high sensibility.  The ratios which enter into the constant of the instrument may be determined experimentally by methods which are comparative and allow an extreme precision.  *The constant can be redetermined at any time.*

The Rayleigh type of current balance as used in this work embodies the advantages of the methods (b) and (c).  It consists essentially of three multiple-layer coils of square cross-section; two large fixed coils and a smaller moving coil.  All of the coils are coaxial and their planes are horizontal.  In this work three pairs of fixed coils (50, 50 and 40 cm. in diameter) and three moving coils (25, 25 and 20 cm.) were used.  The moving coil was suspended midway between the other two from one pan of a precision balance.  The current was led in and out of the moving coil at the balance pan by means of fifty silver wires.  These wires were slack and, on account of their fineness, did not interfere sensibly with the oscillations of the balance.

The force exerted upon the moving coil by the current in the fixed coils was weighed by means of the balance, as follows:  The strength and the direction of the current in the coils were arranged so that the moving coil was pulled down by a force of about 3 g.  This force and the weight of the moving coil were counter-balanced.  Then the rest point *a* of the balance was determined.  The current was then reversed in the fixed coils alone.  The force then became a pull up instead of down, giving a change of about 6 g.  A weight of 6 g. was put on one pan of the balance from which the moving coil was suspended, and very nearly compensated for the change in the force.  Another rest point *b* was taken, the difference between *a* and *b* gave the difference between 6 g. and twice the electrical force upon the moving coil.  The drift of the balance was eliminated by taking a series of the rest points *a* and *b* and plotting these against the time.

The determination of the force in absolute units required the knowledge of the absolute value of the acceleration of gravity.  The value at the Bureau of Standards was determined in terms of the value at the United States Coast and Geodetic Survey by Mr. Wm. H. Berger of the Survey.  Mr. G. R. Putnam of the Survey has connected the latter value with Potsdam by relative pendulum observations.  Thus, the value at the Bureau of Standards has been referred to Potsdam, where, as the result of a long series of observations, the absolute value is

believed to be known to three parts in a million.    On this basis, the absolute value at the current balance is 980.091 cm. per sec. per sec., and is probably correct to five or six parts in a million.

As seen before, the constant $K$ is the rate of change of the mutual inductance with the displacement of one circuit in that direction in which we wish to determine the force.   In the present case then, $K$ is the rate of change of the mutual inductance of two coaxial circular coils, with the displacement of one coil in the direction of the common axis.   The calculation can be simplified by first considering the actual coils to be linear circular circuits of radii equal to the mean radii of the coils.   Then in various ways corrections for the finite sections of the coil can be applied.   Maxwell has derived an exact formula for the mutual inductance of coaxial circles, and by differentiation obtained the expression for the force between them acting along the common axis. The force is given by the equation,

$$F = \frac{\partial M}{\partial B} = \frac{\pi B \sin \gamma}{\sqrt{Aa}} \left\{ 2F\gamma - (1 + \sec^2\gamma) \, E\gamma \right\}$$

where $A$ and $a$ are the radii of the two coaxial circles, $B$ is the distance between their planes, $F\gamma$ and $E\gamma$ are the complete elliptic integrals of argument $\gamma$ and

$$\sin \gamma = \frac{2\sqrt{Aa}}{\sqrt{(A+a)^2 + B^2}}$$

This expression for $F$ can be put in a form where only the ratios $\frac{a}{A}$ and $\frac{B}{A}$ enter, hence $F$ is a function of these ratios alone.   Furthermore, at a certain distance $B$ the force is a maximum, and the coils of the Bureau of Standards current balance were spaced so that this condition was satisfied.   In this case the force becomes practically a function of $\frac{a}{A}$ alone; in other words is determined solely by the *ratio of the radii* of the two circles.

The determination of this ratio is then the important point in the determination of the constant of the instrument.   It was determined experimentally by methods which admit of extreme accuracy.   The principle of the method was identical with that given by Bosscha and used by Lord Rayleigh, but was modified to increase the precision.   The coils to be compared were adjusted concentric and coplanar, with their planes vertical and in the magnetic meridian.   Most of these adjust-

ments were made experimentally. Currents were then passed through the two coils in opposite sense and adjusted until the resultant magnetic field at the center was zero. This was indicated by a magnetometer needle, 2 mm. long. The ratio of the two currents which balance each other in this manner is equal to the inverse ratio of the "galvanometer constants" of the two coils, excepting for a small correction on account of the length of the needle. The ratio of the "galvanometer constants" gives the ratio of the two mean radii when the numbers of turns and the sectional dimensions of the coils are known.

The ratio of the current was measured in two ways which have been called the "potentiometer" and "shunt" methods, respectively. The first method consisted in a simultaneous measurement of the two currents by means of two potentiometers. The second method was employed in cases where, as designed, the coils had nearly the same galvanometer constants. In this method the two coils are joined in series in such a manner that the current flows through them in opposite sense. As used in this work both methods permitted an accuracy of about two parts in a million. The latter method, however, is somewhat the more accurate, considerably more rapid, and requires but one observer. In the table is given the results of a series of measurements of the ratio

| DATE | RATIO | $\Delta$ |
|---|---|---|
| November 28 . . . . | 1.004596 | 3 |
|  | 94 | 1 |
|  | 95 | 2 |
|  | 94 | 1 |
| November 29.. . . . .. . .. | 93 | 0 |
|  | 89 | 4 |
|  | 94 | 1 |
|  | 93 | 0 |
|  | 92 | 1 |
|  | 95 | 2 |
|  | 96 | 3 |
|  | 92 | 1 |
|  | 92 | 1 |
|  | 91 | 2 |
|  | 91 | 2 |
|  | 94 | 1 |
| December 2................ . | 93 | 0 |
|  | 92 | 1 |
| Mean........................ | 1 004593 | 1.4 |

of the galvanometer constants of a small fixed coil (*S*1) and a moving coil (*M*3). The values given have not been corrected for the length of the needle but have had small corrections applied for temperature variations and the heating effect of the measuring current.

The deviations from the mean in parts in a million are given in the third column. The average deviation is 1.4 parts in a million.

One of the features of the current balance which contributed very strongly to the attainment of a high accuracy is the water cooling system. In each of the fixed coils there is a channel back of the windings through which water can be circulated to carry away the heat generated by the electrical current. The supply of water was held at a constant temperature by means of a thermostat, thus maintaining the coils at a constant temperature and radius. Water circulated thru the fixed coils while the constant was being determined and when weighings of the force were being made. During the latter experiment the moving coil was surrounded by a copper water jacket thru which water from the same source was circulated. This served the purpose of carrying away the heat generated in the moving coil and also made constant the convection currents of air which were set up by the heating of the coil. The possible accuracy in the weighing was thereby considerably increased. By the method of weighing the constant lifting force of the currents of air was eliminated.

It was found important to measure the temperatures of the coils when being used. In the determination of the constant and the weighing, the temperature coefficient of the apparatus is zero since only the ratios of the dimensions enter; *provided* all portions are made of the same material and are at the same temperature. Since, however, heat is being generated in some portions and not in other portions, it is evident that the whole apparatus will not be at the same temperature and that the temperature differences will depend upon the quantity of heat generated in the various parts. Hence in this work the temperatures of the coils were measured by measuring the resistance of the windings and corrections were applied to bring all of the parts to the same temperature.

The rest points of the balance were read by means of a tele-

scope and scale and a small mirror mounted upon the central knife edge of the balance. The scale distance was about 2.5 meters. The accuracy of reading, therefore, was equivalent to that which would be obtained with a balance pointer 5 meters long. Thus, it was possible to have the balance very stable and of short period without decreasing the accuracy of the weighing.

Since the intensity of a current cannot be represented by a concrete standard, two expedients have been adopted to preserve the results of the absolute measurement of current. One is to determine the mass of silver deposited per second in a silver voltameter by a current of one absolute ampere, the other is to determine the electromotive force of a standard cell in terms of a standard of resistance and the absolute ampere. In this work the electromotive force of the Weston Normal cell at 20° C. was determined in terms of the international ohm and the absolute ampere. The authors have called the unit of electromotive force a semi-absolute volt. Also, the final result has been expressed in terms of the electrochemical equivalent of silver as determined by a large number of observations with two types of voltameters at the Bureau of Standards.

In the final work four combinations of coils were used, besides one which was not used in taking the mean, owing to a very slight uncertainty in its cross-sectional area, and the following results obtained:

| COMBINATION | E M F OF WESTON NORMAL CELL AN 22° C. | DEVIATION FROM MEAN PARTS IN A MILLION |
|---|---|---|
| $M2$, $L3$, $L4$ . | 1 01822$_8$ | 5 |
| $M3$, $L3$, $L4$. . | 1 01820$_2$ | 21 |
| $M3$, $L1$, $L2$.. | 1.01822$_6$ | 3 |
| $M3$, $S1$, $S2$. ... . | 1 01823$_5$ | 12 |
| Mean .. . . | 1 01822$_5$ | 10 |

The conclusion is that the electromotive force of the Bureau of Standards concrete realization of the mean Weston Normal cell at 20° C. January 1, 1911, was 1.01822 semi-absolute volts. We believe that it is a conservative estimate to assign to the value given above a possible uncertainty due to all causes of two in

100,000 a quantity equal to twice the average deviation from the mean.

The value given by the combination $N4$ L3 $L4$, which was omitted from the mean, was $1.01825_2$.

The weight to be attached to the final mean is considerably increased on account of the fact that three pairs of fixed coils, two large and one small, and two moving coils, of different radii, have been used.   The possibility of the occurrence of appreciable constant errors in the work is thereby very much diminished.

Other observers in England, France and Holland have recently published results obtained by means of various types of instruments.   When reduced to the same basis as used above, the values obtained are as follows:

| | | |
|---|---|---|
| 1907 | Ayrton, Mather and Smith | 1.01818 |
| 1908 | Janet, Laporte and Jouaust | 1 01834 |
| 1908 | Guillet | 1 01812 |
| 1908 | Pellat | 1 01831 |
| 1910 | Haga and Boerema | 1 01825 |
| Mean.. ...... . .... .. ... . .... ......... .. | | 1.01824 semi-absolute volts |

The absolute value of the electrochemical equivalent of silver as obtained from the current balance of the Bureau of Standards and 159 silver deposits made by Rosa, Vinal and McDaniel in this laboratory with two types of voltameters is 1.11804 mg. per coulomb.   The value adopted by the London Conference in 1908 was 1.11800.   In other words, the international ampere as defined by means of the silver voltameter, as used at the Bureau of Standards, differs from the absolute ampere as realized there by means of the current balance by only four parts in 100,000.

When the absolute value of the international ohm is as accurately known as the absolute value of the international ampere is now known, the watt can be realized with high precision from the international watt, by applying as a correction the small difference between them.   Even now the most accurate way of measuring energy or power absolutely is by means of electrical instruments.

ELECTRICITY.—*Resistance coils for alternating current work.* H. L. CURTIS and F. W. GROVER. Communicated by E. B. Rosa. To appear in the Bulletin of the Bureau of Standards.

In an ideal resistance coil for alternating current work two requirements need to be fulfilled in addition to those which are of importance in direct current work; viz, (1) the resistance must be independent of the frequency and (2) the phase angle must be zero. Many of the resistance coils in use at the present time do not even approximately fulfill these conditions. This paper attempts to set forth the principles which must be followed in the construction of satisfactory resistance coils for alternating current work, and to show how to apply them to the design and construction of several coils of different denominations.

The most important thing in the design of a coil whose phase angle is to be small, is to wind it in such a way that its inductance will be a minimum. However there are three other effects which need to be considered in the discussion of the phase angle; viz, (1) "skin effect," (2) capacity between the wires and (3) absorption in the dielectric between the wires. Each of these three causes also gives rise to a change in the effective resistance of the coil when used with different frequencies of alternating current.

Formulas have been developed for computing the value of the "skin effect." By means of these it can be shown that, with the size of wire usually used with coils having a resistance of one ohm and larger, the "skin effect" is in all cases negligible.

The capacity between the wires is in parallel with their resistance and inductance, and is distributed along their length. If $R'$ is the effective resistance of a bifilar coil and $\theta$ its phase angle, then to a first approximation

$$R' = R \left\{ 1 + p^2 C \left( \frac{1}{3} L - \frac{2}{15} C R^2 \right) \right\}$$

$$\tan \theta = \frac{p \left( L - \frac{1}{3} C R^2 \right)}{R}$$

where $R$ is the ohmic resistance of the coil, $L$ its inductance, $C$, the capacity between the two wires, and $p$ is $2\pi$ times the frequency. From this we see that $R' = R$ and $\theta = 0$ only under the condition that both $L$ and $C$ are zero. While this cannot be accomplished in practice, yet if $L$ is made as small as possible and if $L - CR^2 = 0$, then the phase angle will be zero and the change in resistance with frequency negligible. With coils having low resistance (less than 10 ohms) it is difficult to make the capacity large enough to make $L - CR^2 = 0$; but with coils of high resistance (1000 ohms and over) the capacity is usually much larger than it should be. Between these extremes satisfactory coils can be constructed without great difficulty.

In case alternating current is used, the absorption of a poor dielectric between the wires may produce an apparent leakage between turns where the direct current insulation resistance is sufficiently high. The magnitude of the effect of this upon the resistance of the coil will depend upon the resistance of the coil and upon its capacity as well as upon the absorption. Hence while it is entirely negligible for coils of low resistance, it becomes of importance in coils of high resistance. By so designing the coil that the capacity is small, it may usually be made negligible.

By keeping in mind the facts which are stated above, it has been found possible to design coils of denominations from 0.1 to 10,000 ohms in which the change in resistance is less than a part in a hundred-thousand for frequencies up to 3000 cycles per second, and in which the phase angle is not more than 3.5' at 3000 cycles. For $\frac{1}{10}$-ohm, 1 ohm and 10 ohm coils strip manganin, wound in a bifilar manner is used. For 100-ohm coils a single-layer bifilar winding is satisfactory. For 1000-ohm coils fine 200-ohm single-layer bifilar coils are wound on an insulating spool (porcelain is satisfactory) and connected in series. For 10,000-ohm coils a special winding was devised. A tube of biscuit porcelain is cut along a diameter for two-thirds of its length. The winding is then made as follows: One turn is made with a single wire, then the wire passed thru the slit, and a turn made in the opposite direction. The wire is then passed thru the slit and the third turn is made in the same direction as the first, and the process repeated until sufficient wire is upon the spool.

PHYSICS.—*Helium tubes as light standards.*   P. G. NUTTING,
  Bureau of Standards.   Communicated by S. W. Stratton.

The investigation of the properties of electrically conducting
gases with a view to their possible use as primary standards of
luminous intensity has been in progress at the Bureau of Stand-
ards for the past six years.   A summary of the results obtained
is given below, this includes a report of a recent reproducibility
test here given for the first time.

Of the available gases and vapors, helium is the only one emit-
ting light of a suitable color and having reasonable lasting qual-
ities.   The light is of a yellowish white approximately that of
the Hefner flame and of an old type carbon filament glow lamp.
The useful life of a helium tube is from 5 to 100 hours depending
on its construction and operation.   The next best gases would
be carbon dioxide and sulphur, but these emit a snow white light
and disappear rapidly in carrying a current.

The form of tube found most suitable has a capillary portion
of 2-mm. bore, 2-mm. thickness of wall and about 7 cm. long.
The terminal bulbs are 35 mm. in diameter and spherical while
the electrodes are aluminum disks 1 mm. thick and 25 mm. in
diameter.   Recent results indicate that possibly a slightly in-
creased bulb diameter might give longer life to the tubes.

The relation between current and light emitted is very nearly
linear over a wide range of intermediate currents, 10 to 35 m.a.
Twenty-five milliamperes was chosen as the most suitable stand-
ard current.

The ratio of light emitted to internal energy, current times
potential gradient, is not quite constant.   The minimum watts
per candle for a tube of 2-mm. base, namely, 3.8 w./c.p., occurs
at a current between 25 and 30 m.a.   Owing to the large and
uncertain variations in the potential gradient and the difficulties
in its precise determination, attention was directed toward ex-
pressing light in terms of current and bore rather than in terms
of internal energy.

The light emitted by a helium tube as a function of current
was later determined line by line for each of the six prominent
spectrum lines.   These all behave nearly alike, increasing with

current sensibly as does the total light. Helium shows no trace of any secondary spectrum in the visible region.

Neither the voltage nor frequency of alternation of the exciting current affect the light emission by a measurable amount. Voltages of 1, 2, 5 and 10 thousand were used and direct, alternating 60-cycle and 900-cycle current.

Gas density does not affect the specific light emission over a range from 3 to 8 mm. pressure provided the bore of capillary is not much over 2 mm. With 25 m.a. current through 2 mm.-bore, the light is sensibly independent of gas density from 3 to 8 mm. pressure. Chiefly for this reason these specifications and 4 to 7 mm. pressure were adopted for the standard tubes inasmuch as gas density is difficult to control and determine in such tubes.

The correction to the light emitted by a centimeter length of capillary for slight departures from 2 mm. in the bore was carefully determined. It is $-0.010$ c. p./cm. for each $+0.1$ mm. difference in bore from 2.00 mm.

A test for reproducibility was made on a set of forty tubes. The capillary portions of these tubes were specially prepared and selected by Baudin to secure the utmost possible uniformity of bore and wall and freedom from striations. The tubes were made up and filled at the Bureau of Standards.

Color reproducibility was determined by intercomparing the spectra of these tubes line by line with a spectrophotometer. The slight variations observed were well within the errors of observation.

Photometric observations on the mean horizontal candle power per centimeter length of capillary were made by four experienced observers. The computed probable error in the c. p./cm. for all observers and all the tubes was 0.16 per cent. The average deviation of the tubes from their mean value was 1.15 per cent, the maximum deviation 3 per cent. The four different observers read on an average 1.2 per cent below, 0.1 per cent above, 1.5 per cent above and 0.5 per cent below the mean of the four.

The report on reproducibility tests is to be published in the Bulletin of the Bureau of Standards. The preliminary work was reported on in the Bureau of Standards Bulletin 4: 511. 1908; the relation between line intensity and current in same journal, **7**: 65. 1911.

ORGANIC CHEMISTRY.—*Some new compounds of the choline type.* G. A. MENGE, Hygienic Laboratory, Public Health and Marine Hospital Service. Communicated by Walter Wyman. To appear in the Journal of Biological Chemistry.

The synthetic development of compounds of the choline type has been practically limited to choline itself, the so-called homocholines ($\beta$ and $\gamma$) and certain derivatives. The physiological activity of these compounds, as reported in the published work of Hunt and Taveau (Hyg. Lab. Bull. 73) is considered to indicate in a general way that the greatest activity and least toxicity is realized in those compounds which contain the trimethylamine nucleus and in which the alcoholic hydroxyl is not further removed from the nitrogen than the $\beta$ position, suggesting the substitution of the $a$- and $\beta$-hydrogen of the carbon chain as the direction of most promising development from the standpoint of physiological activity.

It would appear that the simplest method of nomenclature for such a class of compounds is to consider them as substituted cholines, $a$ or $\beta$ according to the position of the substituted groups. The author has prepared three new choline compounds in line with the suggested development and certain of their derivatives:

$a$-methyl-choline, $\mathrm{Cl \cdot N} \overset{\diagup(CH_3)_3}{\underset{\underset{\underset{CH_3}{|}}{CH \cdot CH_2OH}}{\diagdown}}$ , a white, crystalline, very

hygroscopic compound, was prepared by converting allyl chloride into methylethylenechlorhydrine and condensing this with trim-

ethylamine; $\beta$-dimethyl-choline, $\mathrm{Cl \cdot N} \overset{\diagup(CH_3)_3}{\underset{\underset{CH_3 \diagup \diagdown CH_3}{CH_2 \cdot COH}}{\diagdown}}$ , a white, crys-

talline, hygroscopic compound was prepared by condensing the chlorhydrine of dimethylglycol with trimethylamine; and $\beta$-$\beta$-

methyl-ethyl-choline, $\mathrm{Cl \cdot N} \overset{\diagup(CH_3)_3}{\underset{\underset{CH_3 \diagup \diagdown C_2H_5}{CH_2 \cdot COH}}{\diagdown}}$ , a crystalline, hygrosco-

pic compound, was prepared by condensing the chlorhydrine of methyl-ethyl-glycol with trimethylamine.

The three compounds were identified and analyzed by means of their platinum salts, which together with the gold salt of α-methyl-choline, are described.    The chlorhydrines used for the disubstituted cholines were prepared from monochloracetone by means of the Grignard's reaction.

Description of the acetyl, phenyl-acetyl, benzoyl, monobrom-isocapronyl, and palmityl derivatives of α-methyl-choline and their platinum and gold salts, already prepared, is reserved for a later paper.

CHEMISTRY OF FOODS.—*Research work of the division of foods of the bureau of chemistry.*    H. W. WILEY.

In the Division of Foods of the Bureau of Chemistry, some of the research work done during the past year is as follows:

Drs. W. D. Bigelow and R. F. Bacon in studying the corrosion of tin plate by canned foods have called attention to the fact that many non-acid vegetables, fish, etc., attack the lining of tin containers to an even greater extent than do the acid fruits.    This kind of corrosive action on tin, which is of very great commercial importance, has not been considered heretofore and is apparently due to the nitrogenous constituents of these foods, especially amines and amino acids.    Dr. Bigelow and his co-workers are continuing the study of the action of various foods on tin plate.

Drs. Bacon and Dunbar have studied the spoilage of tomatoes, detailing the chemical changes in these vegetables, together with methods for detecting the use of spoiled tomatoes in catsups, tomato sauces, etc.    The same chemists have proposed an accurate  and convenient method for determining malic acid in food products.    This method depends on the very large increase in optical activity of this acid when treated with uranium salts. Dr. Bacon has also published during the year methods for the detection and determination of small quantities of ethyl alcohol, methyl alcohol and formic acid.

Mr. H. C. Gore has recently published a work on the processing of persimmons and on the respiration of the fruit.

M. E. Pennington has continued her investigations on the cold

storage of food products, a recent contribution having for its subject Drawn and Undrawn Poultry.

Other recent work includes Enological Studies by William B. Alwood; Estimation of Tin in Canned Goods by Herman Schreiber; and Tomato Catsup under the Microscope by B. J. Howard.

BIOCHEMISTRY.—*The colorimetric and physiological estimation of the active principle of the suprarenal gland.* WORTH HALE and ATHERTON SEIDELL, Hygienic Laboratory. Communicated by Walter Wyman. To appear in American Journal of Pharmacy.

Of the many color tests which have been proposed for the active principle of the suprarenal gland, none appears to have been developed to the accuracy required of a quantitative method. Several have been used for comparative studies on glands from different sources but, so far as shown by the literature, no attempts have been made to correlate the results obtained by color tests with the activity as determined by physiological methods.

In applying a number of the better known color reactions to a series of desiccated suprarenal glands, for the purpose of selecting a suitable one for the forthcoming revision of the U. S. Pharmacopœia, it was noticed that considerable variation in the intensities of the colors from the several samples was obtained; preliminary blood pressure experiments with some of these samples confirmed the differences indicated by the color tests. It thereupon appeared probable that a colorimetric method which would yield results in close agreement with those obtained by the physiological standardization, could be developed.

*The color reaction* selected was that first proposed by Krauss (Apoth. Ztg. **23**: 701. 1908) and independently described by Fränkel and Allers (Biochem. Zeitschr. **18**: 40. 1909); it consists in heating to the boiling point, a mixture of equal volumes of the aqueous suprarenalin solution and dilute (0.2 per cent) $KIO_3$ solution (acidifying with $H_3PO_4$ as proposed by Fränkel and Allers is not desirable), the reddish color being fairly permanent, and well marked even in solutions containing only 1 part of the active principle per 100,000.

*Permanent color standards.* It was found that the color obtained in the reaction just described consisted of a mixture of red and yellow and its tint could be accurately matched by a mixture of about 3 parts of a 1.2 per cent cobalt chloride solution strongly acidified with HCl and 1 part of similarly acidified 0.2 per cent potassium platinic chloride solution. (These solutions are described by the Committee on Standard Methods of Water Analysis.) The intensity of this permanent color standard was then adjusted to correspond exactly with that obtained by mixing 5 cc. of a 1:50,000 solution of the ash free active principle of the suprarenal, with 5 cc. of a 0.2 per cent $KIO_3$ solution (yielding therefore 0.1 mg. active principle per 10 cc.), heating just to the boiling point and after 15 minutes comparing with the color standard in a suitable colorimeter. After standardization, a series of test tubes were prepared with dilutions of the permanent color standard, corresponding to 0.01, 0.02, 0.03, 0.04, 0.06, 0.08 and 0.10 mg. active principle per 10 cc. of solution.

*The determination* of the per cent of active principle in a given sample of desiccated suprarenal is made as follows: 0.01 gm. is placed in a test-tube with 5 cc. of dilute HCl (2.5 cc. 0.1 n HCl diluted to 100 cc. with $H_2O$) and 5 cc. of 0.2 per cent aqueous $KIO_3$ solution, and the mixture heated just to the boiling point, allowed to stand 10 minutes and filtered; the color obtained is compared with the series of standards and its position determined. There may be a slight difference in the tint of the unknown solution due to yellow coloring matter extracted from the desiccated glands, but this difference has so far not been sufficient to interfere with the accurate determination of the position in the series of standards.

Determinations were made upon nine samples of desiccated suprarenal glands obtained from two firms and one sample of 1:1000 solution of the active principle which had been in the laboratory some time. The physiological activity of these same samples was determined by the blood pressure method, using as a basis for the determination the same sample of pure base which had been used to standardize the permanent color tubes required in the colorimetric method. The results are as follows.

| SAMPLE NO | PER CENT ACTIVE PRINCIPLE BY | |
|---|---|---|
| | Colorimetric Method | Physiological Method |
| 362 | 0 6 | 1 0 |
| 363 | 0 6 | 1 2, 1 0, 1 0 |
| 364 | 0 6 | 1 0 |
| 365 | 0 -8 | 1 1, 1 1 |
| 366 | 0 2 | 0 3, 0 2+ |
| 367 | 0 8 | 1 1, 1 0, 1 1 |
| 368 | 0 4 | 0 7 |
| 369 | 0 4 | 0 7 |
| 370 | less than 0 03 | 0 04 |
| 1:1000 solution | 0.03 | 0.035 |

From this table it will be seen that fairly large differences exist in the two sets of values; however, it will be noted that a close parallelism exists between them. The results by the physiological method are some 30 per cent higher in most cases. We are unable at present to account for this but believe that the small amount of yellowish extractive material yielded by the samples is the cause of the lower readings by the colorimetric method. In spite of these variations, however, this test appears to be by far the most satisfactory one at present available and furnishes a means for closely estimating the relative value of different lots of desiccated suprarenal glands and 1:1000 solutions of the active principle. We hope to be able in the near future to extend our experiments to many other samples, both of the desiccated glands and the commercial 1 to 1000 solutions and trust that we will be able to remedy the cause of the present differences in values obtained by the two methods.

In conclusion special attention should be called to the very wide differences in activity found for the various commercial samples of desiccated glands and the considerable diminution in strength of a 1:1000 solution of the active principle. Such wide variations have not so far been reported for the commercial glands and were not expected when we undertook these experiments. They illustrate very forcibly the need of just such a simple method of control of this product as is described in the present paper.

PLANT PHYSIOLOGY.—*The wilting coefficient for different plants and its indirect determination.*[1] LYMAN J. BRIGGS and H. L. SHANTZ. To appear in Bulletin 230, Bureau of Plant Industry.

The object of this investigation was to determine the extent of the variation exhibited by different plants with respect to the minimum point to which they can reduce the moisture content of the soil before permanent wilting occurs. It has heretofore been believed that plants differ widely in this respect and that drought resistance is in part due to the additional supply of water which is available to some plants thru the greater force which they exert upon the soil moisture. The results of this investigation have led us to conclude that the differences exhibited by plants in this respect are much less than have heretofore been supposed, and are so small as to be of no practical utility from the standpoint of drought resistance. As compared with the great range in the wilting coefficients, the small differences arising from the use of different species of plants in determining the wilting coefficient become almost insignificant.

The moisture content of the soil corresponding to the wilting of a plant growing in a confined soil mass is usually spoken of as non-available moisture. We have found that plants are capable of reducing the moisture content of the soil far below that corresponding to the wilting point, and that a steady loss of moisture goes on through the plant tissues even after the death of the plant. The moisture content at the wilting point can not then be considered as non-available, and we have adopted the term wilting coefficient as expressing more specifically the moisture content of the soil corresponding to the permanent wilting of the plant.

The *wilting coefficient* is then defined as the moisture content of the soil (expressed as a percentage of the dry weight) at the time when the leaves of the plant growing in that soil first undergoes a permanent reduction in the moisture content as the result

[1] Presented before the Botanical Society of Washington, October 9, 1911, and before the Philosophical Society of Washington, October 14, 1911.

of a deficiency in the soil moisture supply. By a permanent reduction in the moisture content is meant a condition from which the leaves can not recover in an approximately saturated atmosphere without the addition of water to the soil. In the case of most plants, wilting accompanies the reduction of the water content of the leaves, and is the criterion used to determine the wilting coefficient of a soil for that plant. The definition, as stated, is applicable also to those plants which, owing to structural peculiarities, do not give visible evidence of a reduction of the moisture content of the leaves. The wilting coefficient for such plants is determined by means of the balancing method.

In making wilting coefficient determinations the following precautions are necessary:

1. The soil used should be as uniform as possible.
2. The soil should be brought to a uniform water content before being used.
3. All loss of water should be prevented except that due to the transpiration of the plant.
4. All sudden fluctuations in temperature should be avoided.
5. The moisture determination should be made as soon as the plant has first reached a wilted condition from which it can not recover when placed in a damp chamber.

The method employed consists in growing the plants in a small glass pot, evaporation from the soil surface being prevented by means of a seal of wax which is melted and flowed over the soil surface. In the case of monocotyledons, this wax seal can be applied immediately after planting the seeds, and *the seedlings will grow readily through the wax*, which forms a perfect seal around the stems. In the case of dicotyledons, the wax, which is usually a mixture of paraffin and petrolatum having a low melting point and low heat conductivity, can be melted and flowed around the stems of the seedlings without injury. During growth, the pots are kept immersed in a water bath to avoid condensation of the soil moisture on the pot walls.

When the precautions noted above are observed, the probable error of the mean of the determinations from twelve pots does

not usually exceed one part in a hundred, which is comparable with the accuracy with which the moisture retentiveness of the soil used can be determined by purely physical methods.

The wax seal method is also particularly adapted to the study of transpiration, since all loss of water is avoided except that taking place through the plant.

Wilting coefficient determinations have been made in a series of twenty soils, ranging from sands to clays. In this work, involving about 1300 determinations, a large number of varieties of the different crop plants have been tested, as well as many native plants from the Great Plains.

The results obtained show that species differ only slightly as regards the soil moisture content at which permanent wilting first takes place. Taking 100 to represent the average wilting coefficient, the different species tested give an extreme range (excepting *Colocasia* and *Isoetes*) from 92 for Japan rice to 106 for a variety of corn. Most of the species and varieties tested differ much less than this. On the same scale, the great crop plants gave the following values, obtained by combining the different varieties: corn, 103; wheat, 99; oats, 99; sorgo, 98; millet, 97; barley, 97; rye (one variety only) 94; rice, 94; grasses, 97; legumes, 101.

We are, then, led to conclude that the differences exhibited by crop plants, in their ability to reduce the moisture content of the soil before wilting occurs, are so slight as to be without practical significance in the selection of crops for semi-arid regions. Furthermore, we believe that the slight differences which we have observed are largely due, not to the ability of one variety to exert a greater tractive force upon the soil moisture than another, but to the more perfect root distribution of one variety as compared with another. Drought resistance in certain plants cannot, then, be attributed to their ability to exert a greater force upon the soil moisture, and so gain an additional water supply.

A series of comparisons have also been made of the relative time of wilting of different plants grown together in the same pot. In practically every case, wilting occurred simultaneously, which is in harmony with the above conclusions.

A balancing method has been developed for determining the wilting coefficient for plants in which wilting is difficult to observe, owing to structural peculiarities. The plant is potted in a glazed pot and the soil surface sealed with wax as before. The potted plant is then mounted horizontally in a frame balanced on knife edges. The water transpired by the plant is at first replaced from the supply in the soil. During this time the soil end of the system tends to move upward, owing to the loss of water, and is kept balanced by adjusting a counterpoise. A short period then occurs during which the water lost thru transpiration is supplied both from the soil and from the storage tissues of the plant. During this time the system appears sluggish. Finally the amount supplied from the soil is insufficient to offset the increasing amount lost from the storage tissues of the plant, and the direction of motion of the system is reversed, the plant moving upward. The soil moisture content at this time corresponds to the wilting coefficient of that soil for the particular plant used, since the loss of water from the plant tissues would be accompanied by wilting, except for structural peculiarities.

We have shown by this method that the olive and *Opuntia* undergo a reduction in the moisture content of their aerial parts at the time other plants wilt, altho no outward evidence of such loss is apparent.

That part of the soil moisture content that is available for plant growth is represented by the difference between the actual water content and the wilting coefficient. The latter determination is consequently essential in any critical study of the relation of plant growth to soil moisture. The desirability of a rapid determination of the wilting coefficient in connection with field work led to an investigation to determine whether it could be computed from physical measurements of the moisture retentivity of the soil. A comparison of the wilting coefficient has been made with the moisture equivalent, hygroscopic coefficient, moisture holding capacity, and the mechanical analysis (all expressed in percent), using a series of soils ranging from sand to clay. From this comparison a series of linear relationships have been established as expressed in the following equations, which thus provide

a means of computing the wilting coefficient when direct determinations are not feasible.

$$\text{Wilting coefficient} = \frac{\text{Moisture equivalent}}{1.84\,(1 \pm 0.007)}$$

$$\text{Wilting coefficient} = \frac{\text{Hygroscopic coefficient}}{0.68\,(1 \pm 0.018)}$$

$$\text{Wilting coefficient} = \frac{\text{Moisture holding capacity} - 21}{2.90\,(1 \pm 0.021)}$$

$$\text{Wilting coefficient} = \frac{0.01\ \text{sand} - 0.12\ \text{silt} - 0.57\ \text{clay}}{(1 \pm 0.025)}$$

The second term of the quantity within the brackets shows the probable error of the relationship in each case and constitutes a measure of the relative accuracy of the different methods.

The moisture equivalent method, in which the measurements are made with the aid of the centrifugal machine exerting a force 1000 times that of gravity, is the most accurate and satisfactory of the indirect methods.

# ABSTRACTS

METEOROLOGY.—*Variations of temperature at summit and base stations in the central Rocky Mountain region.* ALFRED J. HENRY. Bulletin of the Mount Weather Observatory, 4: 103-116. 1911.

In this and a previous paper the author discusses the temperatures at summit and base stations in the high Rocky Mountain region of eastern Colorado, as recorded simultaneously by Richard thermographs, the latter being controlled by eye readings of standard mercurial thermometers.

It is shown that as a rule, the course of the temperature at both levels is very nearly parallel, that the accidental changes occur nearly simultaneously, with the exception that changes to warmer weather set in at the upper station earlier than on lower levels, that while the course of the temperature at both levels is generally similarly directed, there are times when it is oppositely directed, as when the temperature rises on the mountain summits and falls on the plains to the eastward. Such instances indicate that the temperature control is occasionally shifted from one side of the mountain to the other and that the mountains then become a real climatic barrier. Ordinarily they offer little or no hindrance to the movement of atmospheric disturbances on which temperature changes depend. In the cold season when the Great Basin is occupied by an area of high pressure the latter seems to dominate the winds and temperature on the higher mountain summits of Colorado and New Mexico but not the plains to the eastward.

The dependence of temperature on altitude is discussed for the pair of stations, Fraser, in Middle Park, Colorado, altitude 2,609 meters, 8,560 feet, and Corona, the latter on the summit of the continental divide, altitude 3,554 meters, 11,660 feet. Although Fraser is 945 meters, 3,100 feet, lower than Corona, it has a temperature that during the night hours and under certain weather conditions is considerably lower than that of Corona notwithstanding the difference in altitude. The cause of the abnormally low temperatures observed at Fraser are

ascribed to the surrounding topography which favors the drainage of cold air down the mountain sides and its accumulation on the valley floor, since there is no easy means of escape. Nocturnal cooling is also at a maximum in the clear dry air of Colorado and it seems to be accentuated under certain types of pressure distribution which prevail over Wyoming and Idaho during the cold season.                     A. J. H.

PHYSICS.—*Selective radiation from various substances III.* W. W. Coblentz. Bulletin Bureau of Standards, Reprint 156. 1911.

The present paper is a continuation of previous work (Bur. Bull. Standards, Reprints 97 and 131) on this subject. The selective emission and absorption of the acetylene flame is investigated spectroradiometrically; also the selective emission of the Welsbach mantle, and of the same material formed into a solid rod which was heated to incandescence electrically.

The conclusions arrived at from the results of the experiments and from historical inquiry are that the selective emission can be explained on a purely thermal basis without invoking the hypothetical and unproven assumption of the presence of "luminescence" and of catalysis.

W. W. C.

PHYSICAL CHEMISTRY.—*Radiometric investigation of water of crystallization, infra-red absorption screens and standard spectral lines.* W. W. Coblentz. Bulletin Bureau of Standards, Reprint 168. 1911. Journal Franklin Institute, October. 1911.

This is a continuation of previous investigations of the condition of water in minerals (Bull. Bur. Standards, Reprint 45). The infra-red transmission of tremolite and of opal are examined *in extenso;* the latter after various stages of de- and rehydration. The spectroradiometric analysis shows no distinction between "water of crystallization," "absorbed water," and "water of solid solution;" all showing the absorption bands of water in its free liquid state. Tremolite is supposed to contain dissolved water but the radiometric test, although sufficiently sensitive for the purpose, failed to detect it. A group of miscellaneous substances is described including gelatin, in which the moisture appears to be present as "water of constitution."                     W. W. C.

CHEMISTRY.—*The determination of total sulphur in india rubber.*
C. E. Waters and J. B. Tuttle. Journal of Industrial and Engineering Chemistry, **3**: 734. 1911. Bulletin Bureau of Standards, **8**: No. 2. 1911.

A comparative study of different methods already published and of variations of these methods. The procedure finally adopted was essentially that of Henriques, except that the nitric acid used to decompose the rubber is saturated with bromine to ensure complete oxidation of free sulphur to sulphuric acid. The methods were tested by using a large uniform sample of rubber, as well as pure sulphur and a solution of sulphuric acid of known strength.                                      C. E. W.

GEOLOGY.—*The Mount McKinley region, Alaska.* Alfred H. Brooks. *With description of the igneous rocks and the Bonnifield and Kantishna districts.* L. M. Prindle. Professional Paper U. S. Geological Survey No. 70. Pp. 234, with maps, sections, and views. 1911.

The Mount McKinley region is blocked out by the meridians 148° and 154° and parallels 61° and 65° 20′ north, but the Alaska Range, which traverses the central part of this region is more specially here under consideration. The Alaska Range is a belt of rugged mountains trending northeast and east 50 to 60 miles wide and from 500 to 600 miles long, of which Mount McKinley (20,300 ft.) is the highest peak. This range was practically unexplored until 1902, when most of the data were collected on which the following conclusions are based.

Undifferentiated Paleozoic sediments, unconformably overlaid by a great complex of volcanic, probably Jurassic, rocks (Skwentna group), and these in turn unconformably succeeded by Middle Jurassic sediments (Tordrillo formation), occur in the eastern part of the range. These rocks dip toward the axis of the range and form the eastern arm of a broad synclinorium. In the western arm the Tordrillo formation rests unconformably on a great series of Paleozoics which has been subdivided into (1) Tatina group (Ordovician), (2) Tonzona group (Silurian or Devonian [?] ), (3) Middle Devonian limestone, (4) Cantwell formation (Carboniferous [?] ). The last, which rests unconformably on the older rocks, has only been recognized in the northern part of the range. Complex folding and profound faulting have taken place along the inland (northern) front of the range, and in this some Kenai beds (Eocene) are involved. Numerous stocks and dikes of granites, diorites, and related rocks, probably of late Jurassic age, occur in the

Alaska Range, and diabase dikes, probably of Eocene age, are not uncommon. Along the northern margin of the range the oldest recognized Paleozoics rest unconformably on complexly folded metamorphoric sediments (Birch Creek schists). Still farther north these metamorphic schists are succeeded by a great thickness of Paleozoics only in part subdivided and correlated with the formations described above. The Mesozoic horizons of the Alaska Range have in part been recognized in the Matanuska Valley of the eastern part of the McKinley region.

An extensive river system was developed in this region during Eocene times, and in this the sediments classed as Kenai were deposited. The northern part of the province was peneplaned in later Tertiary times and it is possible also that the same period of erosion may have baseleveled the southern part of the province. Uplift followed and the modern stream valleys were in part developed along the old Tertiary drainage system.                                              A. H. B.

GEOLOGY.—*Denudation and erosion of the southern Appalachian region and the Monongahela Basin.* LEONIDAS CHALMERS GLENN. Professional Paper U. S. Geological Survey No. 72. Pp. 137, with maps and views. 1911.

Two kinds of aqueous erosion are recognized, namely, (1) stream erosion, confined to the water courses, and (2) general surface erosion, over the whole drainage basin. Stream erosion is continuous but varies greatly in intensity with the amount of water. General surface erosion is due almost entirely to the rain. During heavy rainfall a grass sod absorbs less water than a good humous cover in forested areas and the run-off from grass-land is greater than from forest. The force of the rain drop is lessened in forested areas, and as the fallen drops gather to flow down the slopes they are checked by the leaves and litter or are absorbed by the spongy mass of soft moss or turf. The protective effect of forest cover was noted in many parts of the region. In the course of ages there has come about, in all but a very small part of the area, such an adjustment between the steepness of the forested slope and the average rainfall and other erosive agencies that the wasting of the slope is reduced to a minimum. Streams that flow from such forest-clad graded slopes rise more slowly during rains than similar streams in cleared areas; they also continue longer in flood and subside more slowly. Removal of the forest disturbs the natural equilibrium, excessive erosion takes place, the soil is swept away, and the mountain slopes are scarred.

Other things being equal, the extent and character of erosion varies with the bed-rock. The nature of the rock determines the character of the soil and this determines the kind and rate of erosion.

A. H. BROOKS.

GEOLOGY.—*Geologic Atlas of the United States. Folio No. 177. Bargettstown-Carnegie folio, Penn.* E. W. SHAW and M. J. MUNN. U. S. Geological Survey. Pp. 11, with maps and sections. 1911. *Oil and gas fields of the Carnegie Quadrangle, Penn.* M. J. MUNN. Bulletin U. S. Geological Survey No. 156. Pp. 99, with maps and sections.

The outcropping rocks belong to the Conemaugh, Monongahela, and Greene formations of the Carboniferous system and consist of shale, sandstone, and limestone with minor amounts of coal and clay. Beneath the surface are similar rocks of Allegheny, Pottsville, and Pocono age, and even older rocks have been reached by the drill. The beds dip gently south but the structure is modified by minor irregularities.

Almost all the coal produced is taken from a bed known as Pittsburg coal. This coal outcrops extensively, but in general it is below the surface in the southern half of the district and up near the tops of the hills in the northern half. A few feet above this coal is another bed three or four feet thick known as the Pittsburg rider which is mined to some extent. The oil and gas are found in sandstones 1000 to 2000 feet below the surface, belonging mostly in the Pottsville and Pocono formations.

Two surface features of especial interest are: (1) heavily gravel-covered terraces in the larger valleys of the region lying 200 to 300 feet above present streams and (2) a symmetry in the minor drainage lines of the region, the small tributaries flowing southeast being much longer than those flowing in an opposite direction. E. W. S.

GEOLOGY.—*Geology and underground waters of southern Minnesota.* C. W. HALL. E. O. MEINZER, and M. L. FULLER. Water-Supply Paper U. S. Geological Survey No. 256. Pp. 406, with maps and sections. 1911.

The region here described includes approximately the southern two-fifths of the State of Minnesota and has an area of 28,265 square miles.

Five great rock divisions occur in southern Minnesota. In the order of age, these are the Archean, Algonkian, Paleozoic (here including the Cambrian, Ordovician, and Devonian systems), Cretaceous, and Quaternary. Tertiary stream deposits doubtless exist in some localities,

but they are so unimportant that they have not been differentiated and are here considered with the Quaternary.

In the northwestern and the north-central parts of the area the Archean system, consisting of granite and allied crystallines, outcrops in a number of localities and everywhere lies within a few hundred feet of the surface, but toward the south and east it slopes downward abruptly and is found only at considerable depths. In the southwest the Sioux quartzite, which is of Algonkian age, projects up through younger formations and appears at the surface at numerous localities.

In the east and south, where the granite is far below the surface, it is overlain by a succession of indurated sandstones, shales, and limestones, aggregating many hundreds of feet in thickness, at least the upper part being of Paleozoic age. Throughout most of the western part, and probably in isolated areas of the eastern part, of southern Minnesota, Archean, Algonkian, and Paleozoic rocks are covered by Cretaceous deposits consisting of soft, plastic shales and incoherent sandstones which together attain a maximum thickness of at least 500 feet, though they are generally much thinner. A mantle of glacial drift is spread out over all these formations and, with the exception of the alluvium recently formed in stream valleys, is the youngest deposit in the region.

In regard to their importance in furnishing water supplies, the Pleistocene ranks first and the Paleozoic second, while the Cretaceous and Algonkian are of minor value, and the Archean is virtually destitute of available supplies, everywhere marking the lower limit of water horizons.                                                   H. D. McCASKEY.

ECONOMIC GEOLOGY.—*The Lander and Salt Creek Oil Fields Wyoming: The Lander oil field, Fremont County.* E. G. WOODRUFF. *The Salt Creek oil field, Natrona County.* C. H. WEGEMANN. Bulletin U. S. Geological Survey No. 452. Pp. 87, with maps, sections, and views. 1911.

Viewed as a whole the Lander oil field consists of a central highly dissected ridge with moderately-trenched slightly-undulating plains on either side. The topographic expression of the field is believed to have resulted from the erosion of a plain composed of loose material that once covered the area at a much higher altitude than the present surface and sloped northwestward from the mountains toward the interior of the Wind River Basin.

The strata exposed at the surface in this field belong to the Triassic (?), Jurassic, Cretaceous, Tertiary and Quaternary systems. Below

the Triassic (?) are rocks of Permian (?) and Pennsylvanian age, which do not outcrop in the field but are exposed on the slope of Wind River Mountains. They are entered by some of the oil wells and are believed to be the source of most, if not all, of the oil.

The Triassic (?) is represented by the Chugwater formation, the Jurassic by the Sundance and Morrison formations, and the Upper Cretaceous by the Dakota sandstone, Mancos shale, and the Mesaverde formation. An unconformity separates the Wind River formation (Eocene) from the Upper Cretaceous rocks. The formations, including from the Chugwater to the top of the Upper Cretaceous, aggregates nearly 9500 feet in thickness.

The structural province in which this field lies comprises very broad synclinal basins bordered by relatively high narrow mountain ranges with small steep-sided, slightly elevated anticlines that are exposed about the edges of the basins in a zone between the basins proper and the mountains. If the strata in the interior of the basins are folded, the folds are concealed beneath beds which were deposited subsequent to the major structural movements in the province.

The Salt Creek oil field lies in the northeast corner of Natrona County, Wyoming, and in the drainage basin of Powder River. Topographically the region includes broad flat-topped interstream areas, separated by broad flat valleys. Scarps representing the outcropping edges of hard strata are plentiful. The geologic sequence includes about 6,800 feet of Upper Cretaceous strata, divided into 13 formations. In addition to these, there are the Morrison formation of Jurassic age (?), the Lance formation, which is Tertiary or Cretaceous, and the Fort Union, which is Eocene.

A broad anticlinal arch, more or less faulted, crosses the field in a northwest-southeast direction, the limits of which dip at angles of from 8° to 29°. The steepest dips are found on the west side of the arch. Within this anticline are two domes. To the west of this arch is a second anticline of similar character. The oil occurs at or near the crest of the anticline.                    A. H. BROOKS.

PETROLOGY.—*Geology of the pegmatites and associated rocks of Maine, including feldspar, quartz, mica, and gem deposits.* EDSON S. BASTIN. Bulletin U. S. Geological Survey No. 445. Pp. 152. Illustrated. 1911.

The commercially important pegmatite deposits are principally in the southern and western parts of Maine. Most of the pegmatites are distinctly intrusive into the surrounding schists and granites. They

differ greatly in coarseness but have the common distinguishing characteristic of extreme irregularity of grain. They commonly form long, narrow lenses lying parallel with the foliation of the schists. The associated foliated rocks, which are of unknown age, are in part of igneous and in part of sedimentary origin. The granite and pegmatite are mineralogically similar and numerous observed transitions from one into the other, show that the two are in a broad way contemporaneous and are genetically related.

The pegmatite deposits are essentially coarse granites, their principal light-colored constituents being potash and soda feldspars, quartz, and muscovite, and their principal dark-colored constituents biotite and black tourmaline. Accessory constituents present in almost all pegmatites are garnet, magnetite, and green opaque beryl. Accessory minerals present only in certain pegmatites number over fifty species, the most important probably being lepidolite, emblygonite, spodumene, tourmaline, beryl, topaz, and rose or amethystine quartz. Variations through increase in the sodium and lithium content are responsible for most of the gem deposits of the State.

External conditions, though locally having some slight influence, are not primarily the cause of the pegmatitic textures. The presence of the rarer elements also seems to have had only a minor influence on the texture. Theoretical considerations and the presence of miarolitic cavities in certain pegmatites point to the presence of gaseous constituents in the magmas, especially water vapor, as the primary cause of their textures.

There are many facts which suggest that the difference in average composition between the granite pegmatites and the normal granites was relatively slight and that the pegmatite magmas were not so different in physical characters from the granite magmas as has been commonly supposed.

The theory that the graphic intergrowths in pegmatites represent eutectic mixtures can not be regarded as proved.

Field relations suggest that the large areas characterized by particular abundance of pegmatite intrusions correspond to the roofs of granite batholiths.                                                    E. S. B.

BIOLOGY.—*Development of sponges from dissociated tissue cells.* H. V. WILSON. Bulletin U. S. Bureau of Fisheries, 29: 1-30, pl. i-v. 1911.

Sponges were cut into small pieces and strained thru fine bolting cloth into a dish containing water. The cells settle to the bottom as a fine

sediment, but immediately begin to fuse into conglomerate masses, which in turn unite and metamorphose until the sponge is eventually restored.

The experiments were made chiefly with *Microciona prolifera*, which it was shown can be perfectly regenerated by this method of growth from dissociated cells. *Lissodendoryx carolinensis* is less hardy, and it proved difficult to dissociate the cells in healthy condition, but the behavior of the tissue was the same as in *Microciona*. In *Stylotella heliophila* the behavior of the tissue was slow and feeble as compared with *Microciona*, but the plasmodial masses were formed. In neither of the latter two species, however, did the plasmodial masses metamorphose.

Intermingling of the red tissue of *Microciona* with the bright green of *Lissodendoryx* failed to produce fusion of the different species, as did also the intermingling of tissue of *Microciona* and *Stylotella*.

E. M. SMITH.

FISHERIES.—*Effects of explosive sounds, such as those produced by motor boats and gunshots, upon fishes.* G. H. PARKER. Bureau of Fisheries Document No. 752. Pp. 9. October, 1911.

To the human ear, when the listener is under water, the noise of motor boats and the sound of gunshots, even at very close range, are very slight. Testing fishes in enclosures with the same kinds of sounds the following conclusions were reached:

The sounds produced by motor boats are extremely faint under water and have little influence on the movements and feeding of fishes. Such influence as they do have is temporary and very much restricted in local extent.

Single explosive sounds, like the report of a gun, may startle fish and cause them to cease feeding, but these responses are also temporary and local.

Altho most sounds are repellent to fish, some may serve as lures to particular species.                    E. M. SMITH.

PLANT PATHOLOGY.—*The rusts of grains in the United States.* E. M. FREEMAN AND EDWARD C. JOHNSON, Bureau of Plant Industry, Bulletin 216. Pp. 87, pls. 1. 1911.

This paper embodies results of a detailed study of the grain rusts with regard to distribution, relationships, physiology, and life history. Particular attention is directed to "biologic forms" of rusts, vitality of successive uredo generations, wintering of the uredo generation, climatology in relation to rust epidemics, and methods of breeding grains for rust resistance. Some of the more important conclusions derived follow:

The so-called stem rusts of wheat, barley, rye, and oats are undoubtedly "biologic forms" of the same species, *Puccinia graminis* Pers., and though many of them are highly specialized an interchange of hosts may often be induced by special cultural methods. By gradual variation and adaptation to varying conditions, a rust species widely distributed may form a number of strains or types differing in physiological reactions.

In successive cultures of the uredospores of six different grain rusts, the fifty-second generation was apparently as vigorous as the first in spite of the absence of the aecidium during this period, no "invigoration" having been necessary for this length of time. The uredo of several of the rusts may survive the winter in latitudes as far north as St. Paul, Minn. Rust spores may be carried from one region to another for hundreds of miles by winds and upper air currents.

Subnormal temperatures, delaying and lengthening the heading and early flowering of period the wheat and furnishing conditions most favorable for spore germination and infection, are believed to have been an important factor, if not the determining factor, for the stem rust epidemic of 1904 in the Middle Northwest.

For the prevention of rusts fungicides and soil treatments, as a rule, have proven ineffective, and the only practical method known is the production of rust-resistant varieties through hybridization and selection. To what character resistance is due is not clearly understood. Resistance and susceptibility in cereals, however, are inheritable characters, apparently occurring in Mendelian proportions. In breeding cereals for resistance, the rust must be present in the breeding plants every year. To insure this special methods of rust propagation must be employed.                                              E. C. J.

PLANT PATHOLOGY.—*Timothy rust in the United States.* EDWARD
     C. JOHNSON, Bureau of Plant Industry, Bulletin 224. Pp. 20. 1911.
     Timothy rust was reported from Wisconsin in 1882. There is some doubt concerning the accuracy of this report. It was reported from Iowa in 1891. From 1891 to 1906 no mention of the parasite has been found. In 1906, the rust became epidemic at the Arlington Experimental Farm and since then has been found from Maine to Minnesota, and south to Iowa, Kentucky and Virginia.

Rust on timothy is similar to *Puccinia graminis* Pers. on wheat. Experimental results demonstrate its identity with the rust on timothy in Europe. The aecidial stage is not definitely known. Early indica-

tions that the barberry may be the aecidial host in Europe have not been substantiated. For this reason and because of many other more or less distinctive characteristics of this rust the writer favors the use of the specific name Puccinia Phlei-pratensis Erikss and Henn.

The rust mycelium survives the winter at the Arlington Experimental Farm, producing fresh uredospores in the spring. Its distribution is undoubtedly due to dissemination of the uredospore by the usual agencies, namely, insects, birds, man, other animals, surface winds and upper air currents. Its further distribution is to be expected.

The resistance of varieties of timothy to rust varies greatly. Dependable data on this point can be secured only under epidemic conditions. Breeding of rust-resistant varieties of timothy is the only known method of preventing the disease. This may not be as difficult as it appears at first as timothies thus far have not been highly bred. Varietal differences and variations, therefore, are many, giving promise of marked response to selection.                                E. C. J.

PLANT PATHOLOGY.—*The blister rust of white pine.* PERLEY
    SPAULDING, Bureau of Plant Industry, Bulletin 206. Pp. 88. July
    22, 1911.

As a result of the active and increasing reforestation movement in the northeastern States, white pine nursery stock has been imported from Europe in considerable quantities for a number of years. Small quantities of such stock have been imported for a much longer time. The white pine is attacked in Europe by the fungus *Peridermium strobi*, which is its most serious enemy in Europe, causing very serious loss in nurseries and young plantations. The fungus is widely spread in Europe and has been proved to be one stage of *Cronartium ribicola*, which occurs on currant and gooseberry leaves. The disease also has attacked *Pinus cembra, P. lambertiana*, and *P. monticola*. It also probably has attacked *P. excelsa*. Early in 1909 it was discovered that this disease had been imported extensively into the northeastern States upon young white pine seedlings imported from Germany. Nearly all of the diseased stock has been sent to this country by a single nursery, namely, J. Heins Sons of Halstenbek. As soon as the presence of this disease was known, the various State officials met and agreed to endeavor to prevent it from obtaining a foothold in this country. This has involved repeated inspections of the plantations of diseased white pines and the removal of the species of *Ribes* in the neighborhood of these plantations. Up to the present time the disease is not known to have become established here. Owing to the great danger from importations of white

pine from Europe, the import trade in this stock since 1909 has been reduced to a small amount. In the years 1910 and 1911 only a very few shipments are known to have come into the country from the above mentioned nursery. Diseased shipments have, however, been received from three French firms, thus showing the danger from importations from any European country. The disease has an incubation period during which it cannot be detected by the most skilful plant pathologist. Because of this incubation period, which is of indefinite length, the only feasible plan of handling the situation seems to be the prohibition of the importation of white pine, and of other five-leaved pines, which, so far as we know, are also susceptible to the disease.          P. S.

ENTOMOLOGY.—*Descriptions of Tineoid moths (Microlepidoptera) from South America.* AUGUST BUSCK. Proceedings U. S. National Museum, 41: 205–230. Plates 8–9. 1911.

The material is from the collection of Mr. Wm. Schaus and almost wholly from French Guiana. Forty-five species and the following five new genera are described:

*Filinota*, related to *Carcina; Hasta*, allied to *Anchinia; Gonada*, near *Necedes; Ordrupia*, similar to *Hemerophila;* and *Plumana*, based on a male much like *Fumea*. Twenty-three of the new species are in the genus *Stenoma*. The plates are photographs and do not well illustrate the moths.          N. BANKS.

ENTOMOLOGY.—*Bees in the collection of the U. S. National Museum.* T. D. A. COCKERELL. No. 1. Proceedings U. S. National Museum, 39: 635–658. 1911. No. 2. Ibid., 40: 241–264. 1911.

In these two papers Professor Cockerell describes new species of bees from the United States and Oriental Asia. There are notes of value on many of the described species and frequently closely allied forms are separated by synoptic tables. In the second paper there is a table to the Asiatic species of *Anthophora*. There are no new generic names but new characters are given to distinguish *Viereckella* from *Melanonomada*, both really subgenera of Nomada.          N. BANKS.

ENTOMOLOGY.—*Notes on the distribution of millipedes in Southern Texas, with descriptions of new genera and species from Texas, Arizona, Mexico, and Costa Rica.* O. F. COOK. Proceedings U. S. National Museum, 40: 147–167. 1911.

In the isolated humid spots, now containing certain peculiar millipedes, the author sees evidence of the existence of former forests in

South Texas. *Eurelus* and *Anelus* are the new genera from Texas; three new species of *Onychelus* are described from Arizona, one from the nest of a wood-rat. He also describes from Central America two other two new genera; *Glosselus*, related to *Anelus*, and Centrelus, closely allied to *Eurelus*. One misses the figures that are so useful in papers on myriopods.　　　　　　　　　　　　　　　　N. BANKS.

ENTOMOLOGY.—*Descriptions of new Hymenoptera.* 3 parts. J. C. CRAWFORD. Proceedings U. S. National Museum, **39**: 617, 623; **40**: 439–449; **41**: 267–282. 1911.

Forty-six new species are described from various parts of the world, mostly in the Chalcidae and Proctotrypidae, a few are bees. The following new genera are erected; *Dipachystigma, Winnemana, Sophencyrtus, Leurocerus*, and *Agiommatus*. A table is given for the West Indian species of *Horismenus*. Figures of wings or antennae are given for a few forms which are very useful in identification. The collectors are remembered in the specific appellations.　　　　　　N. BANKS.

ENTOMOLOGY.—*Notes on insects of the order Strepsiptera, with descriptions of new species.* W. D. PIERCE. Proceedings U. S. National Museum, **40**: 487–511. 1911.

This is supplementary to the author's "Monographic Revision" of the order. Twenty-four new species are described, and the following new generic names: *Triozocera, Belonogastechthous, Tachytixenos, Diozocera, Pentozocera. Pentozoe;* three of these are emendations and so synonyms. A host-list is appended giving many new records.
　　　　　　　　　　　　　　　　　　　　　　　　　　　N. BANKS.

ENTOMOLOGY.—*On some Hymenopterous insects from the island of Formosa.* S. A. ROHWER. Proceedings U. S. National Museum, **39**: 477–485. 1911.

A list of nineteen species captured at Horisha by Mr. T. Fukai, of which nine are described as new; no new genera.　　　　N. BANKS.

ENTOMOLOGY.—*The color of the light emitted by lampyridae.* W. W. COBLENTZ. The Canadian Entomologist, p. 355, October. 1911. Phys. Zeitschrift, October. 1911.

The light of various species of fire-flies and of a standard lamp were photographed, and the densities compared by means of spectrophotographic photometry. In this manner the spectral energy curve of the

light of the fire-fly was deduced from a knowledge of the spectral energy curve of the standard lamp. It is shown that the color of the light is not a subjective phenomenon, the maximum emission of the *Pyrophorus noctilucus* being at $0.538\mu$; *Photuris pennsylvanica* being at $0.552\mu$; *Photinus pyralis* being at $0.567\mu$; *Photinus consanguineus* being at $0.578\mu$.

W. W. C.

PSYCHOPATHOLOGY.—*Occupations neuroses (writer's cramp, etc.) recovery after psycho-analytpic measures followed by reëducation.* TOM A. WILLIAMS. Washington Medical Annals. January, 1911. Monthly Cyclopaedia. July, 1911.

The true professional neurosis is psychogenically perpetuated, even though it may have been at first produced by a physical disability. To show this five cases are studied. They are: (1) A right torticolis and cramp of the right arm while counting money. The pathogenesis was traced to an unpleasant incident with a fellow employee who sat behind and to the right while they were counting money in the treasury. The patient's impatience interrupted the great improvement. (2) Writer's cramp in a bank-teller, who refused treatment and had to change occupation. (3) Tremulous writers cramp in a paymaster, which was traced through a psychological mechanism in one interview, which lead to recovery after one month, which persists two and a half years later. (4) Writer's cramp in a woman who always hated correspondence. Cured in four months after unveiling psychological mechanism. (5) Complex multiple cramps in a psychasthenic woman of thirty. After persevering psychoanalysis and arduous education for six months, the patient recovered the power of writing with the right hand.

In no case was a sexual factor found in the genesis. Treatment, after psychoanalysis, consisted of explanation of the mechanism until the patients themselves could expound it: following which psychomotor discipline preceded the reëducation of the professional act. T. A. W.

## PROGRAMS AND ANNOUNCEMENTS
### PHILOSOPHICAL SOCIETY

700th Meeting, November 25, 1911, Cosmos Club at 8.30. Address of the retiring President. ARTHUR L. DAY: *Geophysical Research.*

GEOPHYSICS.—*Geophysical research.*[1]   ARTHUR L. DAY.

To write the history of the earth is a very different undertaking from writing the history of a people.   In the latter case, a diligent seeker can usually find some ancient monastery where far-sighted historians of an earlier generation have collected the more important records which he requires, and placed them within reach of his hand.   With the earth's history, which is the province of geology, it is another matter.   The great globe has been millions of years in the making, and except for a mere fragment of its most recent history, it has had neither a historian nor an observer.   Its formation has not only extended over an almost incomprehensible interval of time, but we have no parallel in our limited experience to help us to understand its complicated development, and no system of classification adequate to the task, even of grouping in an orderly way all the observed rock and mineral formations with reference to the forces which moulded them.   And even if we could correctly interpret all the visible rock records, we are still quite helpless to comprehend all those earlier activities of the formation period, whose record is now obliterated.

To the student of the earth's history, therefore, the problem of gathering and ordering such a widely scattered and heterogeneous collection of effects and causes is one of somewhat overwhelming scope and complication.   In the industrial world, a situation of this kind soon results in replacing individual effort with collective effort, in the organization of a system of a scope

[1] Presidential address delivered at the 700th meeting of the Philosophical Society of Washington, November 25, 1911.

more appropriate to the magnitude of the task.    We are familiar
with industrial organization and the wonderful progress in the
development of American industries which has everywhere fol-
lowed it.    We are also familiar with organized geological sur-
veys and the success which has attended them in geological and
topographical classification.    But the idea of organizing research
to meet a scientific situation of extraordinary scope and com-
plexity is still comparatively new.    The very words science
and research are still regarded as referring to something out of
the ordinary, something to be withheld from the common gaze,
to be kept hidden in a special niche, behind a mysterious curtain
and served by priests of peculiar temperament and unpractical
ideals.    This is both disparaging to our good sense and prejudi-
cial to the progress of knowledge.    Scientific research is not a
luxury; it is a fundamental necessity.    It is not a European fad,
but is the very essence of the tremendous technologic and indus-
trial success of the last twenty years, in which we have shared.

Professor Nichols, of Cornell, as retiring president of the Amer-
ican Association for the Advancement of Science, put the case in
this way "The main product of science (research)   .   .   .   is
knowledge.    Among its by-products are the technologic arts,
including invention, engineering in all its branches, and modern
industry."    The idea of scientific research is therefore not less
tangible than industrial development, or less practical; it is merely
one step more fundamental; it is concerned with the discovery
of principles and underlying relations rather than their applica-
tion.    This being true, research should profit as much, or even
more, from efficient organization as industrial development has
done.

Altho this conclusion is making its way but slowly in Amer-
ican science, in geological research, where material must be
gathered from the utmost ends of the earth and even from within
it, and where nearly every known branch of scientific activity
finds some application, there is a peculiarly favorable opportunity
for organized effort which is already coming to be recognized.
"So long as geology remained a descriptive science," says Presi-
dent Van Hise of Wisconsin, "it had little need of chemistry and

physics; but the time has now come when geologists are not satisfied with mere description.   They desire to interpret the phenomena they see in reference to their causes—in other words, under the principles of physics and chemistry.   .   .   .   .   This involves coöperation between physicists, chemists and geologists."

In a general way, physics, chemistry and biology have already supplied working hypotheses which have been used by students of geology to help in the examination, classification and mapping of the most conspicuous features of the exposed portion of the earth.   The geologist has gone abroad and has studied the distribution of land and water, the mountain ranges, the erosive action of ice and of surface water and the resulting sedimentary deposits, the distribution of volcanic activity and of its products, the igneous rocks; or more in detail he has studied the appearance of fossils in certain strata, and has inferred the sequence of geologic time.   The distribution of particular minerals and of ore deposits has been carefully mapped.   Regions which offer evidence of extraordinary upheaval thru the exercise of physical forces have been painstakingly examined, and so on thru the great range of geologic activity.   In a word, the field has been given a thoro general examination, but the manifold problems which this examination has developed, altho early recognized, and often the subject of philosophical speculation and discussion, still await an opportunity for quantitative study.   They are often problems for the laboratory and not for the field, problems for exact measurement rather than for inference, problems for the physicist and chemist rather than for the geologist.   This is not a result of oversight, it is a stage in the development of the science, —first the location and classification of the material, then the laboratory study of why and how much.

Certain indications have led us to believe, for example, that the earth was once completely gaseous and in appearance much like our sun.   Indeed, it possibly formed a part of the sun but thru some instability in the system became split off—a great gaseous ball which has cooled to its present condition.   The cooling probably went on rapidly at first until a protecting crust formed about the ball, then more and more slowly, until now, when our

loss of heat by radiation into space is more than compensated by heat received from the sun. Obviously, the earliest portions of this history are and must remain dependent upon inference but the formation of a solid crust cannot advance far before portions of it become fixed in a form such that further disturbance does not destroy their identity. From this point on the history of the earth is a matter of record and can be interpreted if only we have sufficient knowledge of the mineral relations thru all the stages of their development.

It must have been a very turbulent sea, the molten surface of our earth upon which the rocky crust began to form. The first patches of crust were probably shattered over and over again by escaping gases and violent explosions of which our waning volcanic activity is but a feeble echo. If the earth was first gaseous, and the outer surface gradually condensed to a liquid, its outer portions at least must have been whirled and tumbled about sufficiently, even in a few thousand years (which is a very small interval in the formation of an earth), to mix its various ingredients pretty thoroly. It has accordingly been hard to see just how it came to separate into individual rocks of such widely different appearance and character. Of course the number of its ingredients was large. We have already discovered eighty or more different elementary substances in the earth, and there is an almost endless number of more or less stable compounds of these. The freezing of an earth is therefore different from the freezing of pure water, but the freezing of salt water offers a clue to the explanation of the way in which the earth solidified as we find it. When salt water freezes, the salt is practically all left behind. The ice contains much less salt and the remaining water relatively more salt than before freezing began. Applying this familiar observation to the supposed molten surface of the earth as it begins to solidify, we have a suggestion of order and reason in its separation into so many kinds of rocks.

Now, it happens that in the recent development of chemistry much attention has been given to the study of solutions of various kinds, and a great body of information has been gathered and classified of which our observation upon the freezing of salt water

is a simple type. Still more recently (quite lately in fact), it has occurred to many students of the earth that here lies not only the clue but perhaps the key to their great problem. If the individual components which are intimately mixed in solution separate wholly or partially in some regular way upon freezing—and nearly all the solutions which have been studied appear to show such segregation—we have a quantitative system which will probably prove adequate to solve the problem of rock formation, provided only that the experimental difficulties attending the study of molten rock and the complications imposed by the presence of so many component minerals, do not prove prohibitive. This is a very simple statement of the point of view which has led to the experimental study of rock formation in the laboratory as a natural sequence to statistical study in the field.

Geophysics therefore does not come as a new science, nor as a restricted subdivision of geology, like physiography or stratigraphy, but rather to introduce into the study of the earth an element of exactness, of quantitative relation. It may include physics or chemistry, biology or crystallography or physical chemistry, or all of these at need. The distinctive feature of geophysics is not its scope, which may well be left to the future, but its quantitative character. The Geophysical Laboratory of the Carnegie Institution at Washington has entered upon some of the investigations suggested by this long preliminary study of the earth,—the physical properties and conditions of formation of the rocks and minerals. The Department of Terrestrial Magnetism of the same institution has undertaken another,—the earth's magnetism; the German Geophysical Laboratory at Göttingen a third,—the earthquakes—and these will no doubt be followed by others.

The first effect of calling exact science into consultation upon geologic problems is to introduce a somewhat different viewpoint. It has been our habit to study the minerals and the rocks as we find them today, after many of the causes which have had a share in their evolution have ceased to be active,—after the fire has gone out. If we attempt to reconstruct in our minds the operations which enter into the formation of an igneous rock or

of a body of ore, we must infer them from present appearances
and environment.   The experimental geophysicist, on the other
hand, confronting the same problem, says to himself: Can we
not construct a miniature volcano in the laboratory, Can we not
build a furnace in which an igneous rock can be formed under
such conditions that we can observe its minutest change?   He
proposes to introduce temperature measuring devices and appara-
tus for the determination of pressure, to investigate the character
of the surrounding atmosphere and the quantity of water vapor
which may be present.   He insists upon the chemical purity of
every ingredient which goes into the furnace and guards it care-
fully against contamination.   In these various ways he will
undertake to ascertain the exact magnitude of all the causes, both
physical and chemical, which have been at work in his miniature
rock-producer, together with the physical characteristics of the
product.

A very practical question now arises.   Can he do all this suc-
cessfully at the temperatures where the minerals form?   We must
press this question and insist upon a satisfactory answer, for
it is by no means obvious that the relations which the physicist
and chemist have established at the temperatures of everyday
life—energy content, density, solubility, viscosity, dissociation—
will continue to hold when substances are carried up to a white
heat.   The substances, too, are different from those with which
the chemist and physicist have been generally familiar.   Instead
of simple metals, aqueous solutions, and readily soluble active
salts, we encounter silicates and refractory oxides, inert in behav-
ior and capable of existing together in mixtures of great complexity.
We must therefore extend the range of our physics and our chem-
istry to a scope in some degree commensurate with the wide range
of conditions which the earth in its development has passed thru.
Let us follow for a little the actual progress of such an attempt.

The first step is to provide the necessary temperatures.   Obvi-
ously, the common fire-clay crucible and the smelter's furnace
with its brick lining, will not serve us, here, for all these are them-
selves mineral aggregates.   The charge, furnace lining, and
crucible would go down together in a fall as disastrous as Humpty

Dumpty's. But experiment has taught us that platinum crucibles, magnesia furnace tubes enclosing an electrically-heated helix of platinum wire, and electric temperature-measuring devices, provide a furnace in which nearly all of the important minerals can be successfully studied, which is not enough to melt zinc, silver, gold, copper, nickel or iron readily, and where any temperature up to 1600° Centigrade can be maintained perfectly constant if need be for several weeks. All these temperatures can be measured with no uncertainty greater than 5°. This equipment preserves the chemical purity of the mineral studied, and enables the temperature to be controlled and measured at every step of the experimental work. Or an iridium furnace tube and an iridium crucible can be substituted for platinum, the magnesia supports can still be used, and we have it in our power to go on to 2000° C., which is quite sufficient for all the more important minerals which we know.

The physicist has therefore found a suitable melting pot, and means of ascertaining what goes on within the pot; but he at once encounters another difficulty. Nature has provided us with relatively few minerals of high chemical purity. If a natural mineral is chosen for experiment, however typical it may be, several per cent of other minerals may be expected to be present with it, the effect of which is at present quite unknown. Now, the first axiom of the investigator in a new field who desires to undertake measurements which shall have a real value, is that the number of unknown quantities in his equations must not be greater than he can eliminate by his experimental processes; in other words, he must begin with conditions so simple that the relation between a particular effect and its cause can be absolutely established without leaving undetermined factors. Having solved the simple case, it is a straightforward matter to utilize this information to help solve a more complicated one. If we would therefore reduce the mineral relations to an exact science, which is our obvious purpose, it is necessary from the outset to prepare minerals of the highest purity and to establish their properties. Having obtained such a pure mineral type, it may be, and often is, in the power of the mineralogist and his microscope to determine,

by direct comparison with its natural prototype, the kind and amount of effect actually produced in the natural mineral by the one or more other minerals which it contains. We have therefore hardly started upon our investigation before the need of an organized system is demonstrated,—first comes the chemist, who prepares and analyzes the pure mineral for investigation; then the physicist, who provides and measures the conditions to which it is subjected; then the mineralogist, who establishes its optical properties in relation to the corresponding natural minerals.

Having prepared such a mineral, of high purity and of known crystalline character, we can ascertain its behavior at the temperatures which must have obtained during the various stages of earth formation. We can study the various crystal forms thru which it passes on heating and the temperature ranges within which these forms are stable; we can also melt it and measure the melting or solidifying temperature. Another mineral, prepared with the same care and studied in the same way, may afterward be added to the first, and the relation of these two determined. If they combine, heat is absorbed or released; and this quantity of heat can be measured, together with the exact temperature at which the absorption or release takes place. If the mixture results in the formation of one or more mineral compounds, we shall learn the conditions of formation, the temperature region within which the new forms are stable, and the changes which each undergoes with changes of pressure and temperature, as before. If the new forms show signs of instability, we can drop them into cold water or mercury so quickly that there will be no opportunity to return to initial stable forms, and thus obtain, for study with the microscope at our leisure, every individual phase of the process thru which the group of minerals has passed.

Without complicating the illustration further, it is obvious that we have it in our power to reproduce in detail the actual process of rock formation within the earth, and to substitute measurement where the geologist has been obliged to use inference; to tabulate the whole history of the formation of a mineral or group of minerals under every variety of condition which we may sup-

pose it to have passed thru in the earth, provided only we can reproduce that condition in the laboratory.

During the past quarter of a century, there has arisen in the middle ground between physics and chemistry a new science of physical chemistry, in the development of which generalizations of great value in the study of minerals have been established. As long ago as 1861 the distinguished German chemist, Bunsen, pointed out that the rocks must be considered to be solutions and must be studied as such; but inasmuch as comparatively little was known about solutions in those days, and the rocks at best appeared to be very complicated ones, no active steps in that direction were taken during Bunsen's life. But in recent years solutions have been widely studied, under rather limited conditions of temperature and pressure, to be sure, but it has resulted in establishing relations—like the *phase rule*—of such effective and far-reaching character, that now, just half a century afterward, we are entering with great vigor upon the prosecution of Bunsen's suggestion. It is now possible to establish definite limits of solubility of one mineral in another, and definite conditions of equilibrium, even in rather complicated groups of minerals, which enables us not only to interpret the relations developed by such a thermal study as that outlined above, but also to assure ourselves that only a definitely limited number of compounds of two minerals can exist, that they must bear a constant and characteristic relation to each other under given conditions of temperature and pressure, and that changes of temperature and pressure will affect this relation in a definite and determinable way. Physical chemistry not only takes into account the chemical composition of mineral compounds, but their physical properties as well, thruout the entire temperature region in which they have a stable existence, and therefore furnishes us at once with the possibility of a new and adequately comprehensive classification of all the minerals and rocks in the earth. The value of an adequate system of classification appeals chiefly to those whose duties bring them into intimate relations with the subject matter of a science, but so much may appropriately be said, that a consistent application of physical chemistry to the minerals may

operate in the not far distant future to develop an entirely new conception of the science of mineralogy.

As the number and scope of such exact measurements increase, we gradually build up what may be called a geologic thermometer. Just as the location of fossils offers a basis for estimating geologic time, it often happens that a mineral takes on a variety of different crystal habits, according as it happened to form at one temperature or another. Quartz, for example, which is one of the commonest of natural minerals and one of the most familiar, undergoes two changes in its crystal form which leave an ineffaceable record. One occurs at 575° and the other at 800°. An optical examination of even a minute quartz fragment from the mountainside will reveal to the skilful petrologist whether the crystal formed at a temperature below 575°, between 575° and 800°, or above 800°. And if we could have at our disposal a great body of such exact measurements of the temperature region within which particular crystals originate and remain stable, we could apply that directly to terrestrial formations in which this mineral occurs, and read therein the temperature which must have obtained during their formation. All this will not be done in the first year, and perhaps not in the first decade; but the ultimate effectiveness of this method of procedure in establishing the relations between the minerals and the valuable ores is now as certain of success as the operations of any of the sciences which have now come to be characterized as exact, as opposed to descriptive.

There is one important difference between the great laboratory of nature and its feeble human counterpart. Nature operated with large masses, mixed with a generous hand, and there was always plenty of time for the growth of great individual crystals, at which we marvel whenever we encounter them, and which we have sometimes come to regard highly as precious stones. To carry these processes into the laboratory is necessarily fraught with certain limitations. The quantities must remain small and the time and available financial resources will always be limited. So long as we are able to ascertain the optical character of a crystal with equal exactness whether the crystal is of the size of the

proverbial mustard-seed or a walnut, the scientific laboratory cannot properly afford the time necessary to produce the large crystals which nature offers so abundantly. Furthermore, the crystals of nature often owe their brilliant coloring to slight admixtures of impurity, which, to the scientific laboratory, spell failure and are avoided with the utmost care. Most of the mineral crystals, when reproduced in the laboratory, are quite colorless. And so, altho the question is often raised whether we are not really engaged in the artificial production of gems, and altho the seductive character of such an investigation would no doubt appeal to many, it must be admitted that the geological laboratory is not and probably will never become the serious competitor of nature in those directions in which nature has produced her most brilliant effects.

In what has preceded, I have laid emphasis upon the value of experimental measurements in the systematic development of a more exact science of the earth. It is a fair question, and one which is very often raised, whether all this investigation has a utilitarian side, whether the knowledge obtained in this way and with such difficulty, will help to solve any of the problems arising in the exploitation of our mineral resources or assist in our industrial development. It is neither wise nor expedient, in entering upon a new field of research, to expatiate long upon its practical utility. Its principles must first be established, after which there is no lack of ingenuity in finding profitable application of them.

The development of thermoelectric apparatus for the accurate measurement of high temperatures was begun and has been perfected in the interest of geophysical research, and it has already found such extended application among the technical industries as to demand the manufacture and calibration of thousands of such high temperature thermometers every year. The tempering and impregnation of steel are no longer dependent upon the more or less trained eye of the workman, but are done at measured temperatures and under known conditions which guarantee the uniformity of the product and admit of adaptation to particular purposes, like high speed tools or armor plate. This has the incidental but far-reaching industrial consequence that workmen

of great individual skill in these industries are much less neces-
sary now than formerly.    Everything is accomplished by bring-
ing temperature conditions under mechanical control and mak-
ing them absolutely reproducible without the exercise of critical
judgment on the part of anyone.

A more intimate knowledge of the behavior of the minerals
themselves finds almost immediate industrial application.    An
industry which has grown to enormous proportions in recent
years is the manufacture of portland cement, about which little
more has been known than that if certain natural minerals were
taken in the proper proportions and heated in a peculiar furnace
developed by experience, the resulting product could be mixed
with water to form an artificial stone which has found extensive
application in the building trades.    Chemical analysis readily
established the fact that the chief ingredients in a successful
portland cement were lime, alumina and silica, with a small admix-
ture, perhaps, of iron and magnesia; but the relation in which
these ingredients stood one to another,—that is, which of them
were necessary and which merely incidental,—and in what
compounds and what proportions the necessary ingredients
required to be present, has never been satisfactorily established.
When we know the stable compounds which lime, alumina and
silica can combine to form, together with the conditions of equi-
librium between these for different temperatures and percentages
of each component, a formula can be written offhand for a success-
ful portland cement from given ingredients somewhat as an experi-
enced cook might write out the recipe for a successful dish.    Such
definite and valuable knowledge is not beyond our reach.    To
obtain it requires, in fact, precisely the same system of procedure
which has been described above and which has already been suc-
cessfully applied to many of the natural minerals which have been
reproduced and studied in the Geophysical Laboratory during
the past five years.    It happens that we have examined a con-
siderable number of these very mixtures in our recent work upon
the rocks.    All the compounds of lime, silica and alumina have
been established, and a portion of the silica-magnesia series, and
their relations have been definitely determined thruout the

entire range of accessible temperatures. There is no reason to apprehend serious difficulty in applying the same procedure to the commercial ingredients of portland cement, and replacing the present rule-of-thumb methods and uncertain products with dependable cements. The problem of determining the relation of the ingredients in commercial cement and the conditions necessary for its successful formation is exactly the same in character as that of determining the conditions of formation of the rocks of the earth.

A physico-chemical investigation of the sulphide ores over a wide range of temperatures and pressures has also been undertaken, which has developed a large body of exact information of value in mining industry. And such illustrations could be continued almost indefinitely, if it would serve any useful purpose to do so.

The industrial world is not as a rule interested in scientific principles; the principle must first be narrowed down to the scope of the industrial requirement before its usefulness is apparent. The immediate effect of an industrial standpoint is therefore to restrict investigation at the risk of losing sight of underlying principles entirely. An illustration of this has come down to us thru the pages of history, of a character to command and receive the utmost respect, for such another can hardly be expected to occur. We have honored the early philosophers for their splendid search after broad knowledge; but in what is now the field of chemistry, they allowed themselves to be turned aside to the pursuit of a single, strictly utilitarian problem,— the transmutation of base metals into gold. The history of chemistry is a history of this one problem from the fourth to the sixteenth century,—twelve centuries before a man arose whose broader standpoint enabled him to divert the fruitless search into other channels from which a science has slowly arisen which is now so broad as to overlap most of the other sciences, and withal so practical that hardly an industry is entirely independent of it.

The so-called practical questions may therefore as well be left to take care of themselves. There has been no lack of ingenuity in making profitable application of systematic knowledge when-

ever the need for it became insistent, for the rewards of such effort are considerable. And it is no longer an argument against proceeding to establish relationships in a new field, that the scope of their application cannot be completely foreseen.

Now, what more promising questions occur to one than these: If the earth was originally fluid, as it appears to have been, and has gradually cooled down to its present state, its component minerals must at some time have been much more thoroly mixed than now; how did they come to separate in the process of cooling into highly individualized masses and groups as we now find them, and what were the steps in their deposition? If the whole earth was hot, whence came the marble of which we have so much and which can withstand no heat? What has given us the valuable deposits of iron, of gold, of precious stones? What determines the various crystal forms found in the different minerals, and what is their relation? Some must have formed under pressure, some without pressure, some with the help of water, and some without. Where is the center, and what the source of energy in our volcanoes? All these questions, and many more, the geophysicist may attempt to answer.

PHYSICS.—*A correlation of the elastic behavior of metals with certain of their physical constants.* JOHN JOHNSTON. Communicated by A. L. Day.

As is well known, the effect of pressure acting on both the solid and liquid phase of a single substance is to raise or lower its melting point according as the process of melting is accompanied by an increase or a decrease of volume respectively, the latter being the exceptional case. But, when pressure acts only on the solid phase, but not—or not to the same extent—on the liquid phase, the melting point is always lowered and by an amount which is many times as great as the corresponding change produced by the same pressure acting on both the liquid and the solid phase.

It seemed of interest to calculate the effect of pressure, acting on the solid phase alone, in lowering the melting point of metals, and to compute the amount of such unequal pressure required

to cause the metal to melt at, or about, 25°. The method of calculation follows.

The application of thermodynamical principles to this case yields the differential equation.[1]

$$\frac{dT}{dP} = \frac{T_1}{QD} \quad \dots\dots\dots\dots\dots\dots (I)$$

which when integrated so as to be applicable to the case in hand becomes

$$\frac{\Delta T_1}{\Delta P} = \frac{T_1}{42.72 Q_1 D_1} \quad \dots\dots\dots\dots\dots (II)$$

according to which the change in melting-point $(\Delta T_1)$ produced by a pressure $(\Delta P)$ acting only on the solid phase is expressed in terms of the melting point $(T_1)$ at atmospheric pressure, the heat of melting $(Q_1)$, and the density $(D_1)$ of the solid at ordinary temperature and pressure.

Lack of space precludes a discussion, and justification, of the assumptions involved in obtaining this integrated form of equation I; suffice it to say that the matter has been carefully considered, and that any inaccuracy in this integration is quite unimportant in the present connection, more especially since the accuracy of the available values of $Q_1$ (and even of $D_1$) leaves much to be desired.

The above formula has been applied to the calculation of the lowering of melting point produced by 1 atmosphere excess pressure on the solid in the case of all the metals[2] for which values of

[1] A succinct mode of deriving this equation is given by G. N. Lewis (J. Am. Chem. Soc., **30**: 680. 1908).

[2] Excepting iron, on account of the uncertainty of what "iron" is, and the disparity of the recorded values. The value given for nickel in Landolt-Börnstein-Meyerhoffer Tabellen (p. 470) as a heat of fusion (taken from Pionchon, Ann. chim. Phys., (6), **11**: 106. 1887) was found, on reference to the original, to be a heat of *transformation* (occurring somewhere between 230° and 400°); consequently nickel could not be included. (Similarly, Pionchon's values for iron given in L.-B.-M. (p. 470) are heats of *transformation*.) Mercury and gallium are omitted, since they are liquid at ordinary temperatures. The value of $Q$, for aluminium is somewhat doubtful: it was calculated from the "total heat" (as given in L.-B.-M.) by means of the specific heat of aluminium (0.30) as given by Bontschew (L.-B.-M., p. 383). No alloys could be included, owing to lack of the necessary data; in any case the formula is applicable only to those alloys which melt at a definite temperature.

$Q_1$ are given in Landolt-Börnstein-Meyerhoffer Tabellen (2 Aufl. p. 470). For some metals more than one value is given, but it is at present impracticable to determine which are most reliable; for this reason, the mean value was adopted in all such cases. For the same reason, the general mean value of the density, as given in the tables (pp. 224–9) was taken. The melting points are those now generally adopted. The data and results are brought together in Table 1.

TABLE 1

LOWERING OF MELTING POINT OF METALS EFFECTED BY UNEQUAL PRESSURE

| METAL | MELTING POINT | | HEAT OF FUSION | DENSITY | | |
|---|---|---|---|---|---|---|
| | $t$ | $T_1$ | $Q_1$ | $D_1$ | $\Delta T_1$ | $\varphi_{25}$ |
| K | 62 | 335 | 15 7 | 0 87 | 0 574 | 64 |
| Na. | 97 | 370 | 31 7 | 0 98 | 0 279 | 290 |
| Pb | 327 | 600 | 5 4 | 11 37 | 0 229 | 1320 |
| Sn. | 232 | 505 | 14 1 | 7 29 | 0 115 | 1800 |
| Bi.... | 270 | 543 | 12 5 | 9 80 | 0 104 | 2360 |
| Cd. | 321 | 594 | 13 7 | 8.64 | 0 117 | 2520 |
| Al. ... | 658 | 931 | 42 | 2 60 | 0 200 | 3170 |
| Zn | 419 | 692 | 28 | 7 1 | 0 081 | 4840 |
| Ag.... | 960 | 1233 | 23 | 10 50 | 0 120 | 7820 |
| Cu. | 1083 | 1356 | 43 | 8 93 | 0 083 | 12800 |
| Pd.. | 1550 | 1823 | 36 3 | 11 4 | 0 103 | 14800 |
| Pt ... | 1755 | 2028 | 27 2 | 21 5 | 0 081 | 21300 |

The last column of Table 1 contains the values (in atmospheres) of the excess pressure (acting on the solid only) required to cause the metal to melt at 25°; these were calculated from the expression

$$\varphi_{25} = (T_1 - 298) / \Delta T_1 \dots \dots \dots \dots \dots (III)$$

The metals are arranged in the order of increasing values of $\varphi$ calculated in this way. It was conjectured that this order might bear some relation to that obtained when these metals are arranged with reference to the relative values of their elastic constants and mechanical properties.

The most obvious mechanical property with which to compare the series of $\varphi$ values is the flow-pressure. This was deter-

mined by Tammann, Verigin and Levkojeff[3] for a series of metals. Arranged in the order of decreasing ease of flow, the metals follow in the order K, Na, Pb, Tl, Sn, Bi, Cd, Zn, Sb, a sequence which is identical with that deduced thermodynamically and presented in Table 1.    But not only is the sequence of $\varphi$ values identical with that of the flow pressure, it is practically identical with the sequence obtained when the metals are arranged in the order of *any* of their elastic properties for which measurements have been made.    This is shown by Table 2, in which have been brought

TABLE 2

RELATIVE VALUES[4] OF THE ELASTIC CONSTANTS OF METALS

| METALS IN ORDER AS IN TABLE 1 | COMPRESS-IBILITY | HARDNESS | TENSILE STRENGTH | | ELASTIC LIMIT | | | ELASTIC (YOUNG'S) MODULUS | RIGIDITY MODULUS | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Lower | Upper | | | |
| | (a) | (b) | (c) | (d) | (e) | (f) | | (g) | (h) | (i) |
| K         . | 31 5 | 0 5 | | | | | | | | |
| Na...    . | 15 4 | 0 4 | | | | | | | | |
| Pb ....... | 2 2 | 1 5 | 2 0 | 21 | 0 3 | 25 | 102 | 17 | 5 | 0 80 |
| Sn.. .... | 1 7 | 1 8 | 2.1 | 36 | 4 | 34 | 55 | 34 | 16 | 1 50 |
| Bi.... | 2 S | 2 5 | | | | | | 32 | 12 | |
| Cd | 1 9 | 2.0 | | 4S | | 2S | 109 | 71 | 17 | 2 31 |
| Al ..... .. | 1 3 | 2.9 | | | | 2S3 | 600 | 70 | 29 | 2 55 |
| Zn...... | 1 5 | 2 5 | 13 | | 10 | 125 | 770 | 78 | 31 | |
| Ag...... ... | 0 S4 | 2.7 | 22 | 272 | 12 | | | 70 | 39 | 2 67 |
| Cu  .. . . | 0 54 | 3 0 | 25 | 316 | 12 | 203 | 27S0 | 10S | 42 | 4 37 |
| Pd.......... . | 0 3S | 4 S | | | 27 | | | 103 | 46 | |
| Pt..... ........ | 0 21 | 4 3 | 29 | | 26 | | | 161 | 52 | 6 46 |

(a)   As given by Richards and collaborators, J. Am. Chem. Soc., 31: 156.    1909.

(b)   According to Rydberg, L.-B.-M. Tabellen, p. 57.

(c)   L.-B.-M. Tabellen, p. 53.

(d)   Wertheim (184S) quoted by Faust and Tammann, Z. Physik. Chem. 75: 118.   1911.

(e)   L.-B.-M. Tabellen, p. 53.

(f)   As determined by Faust and Tammann, loc. cit.

(g) (h)   General mean of the (sometimes very discordant) values given in. L.-B.-M. Tabellen, pp. 43–45.

(i)   Horton, Phil. Trans. Roy. Soc. London, A, 204.   1905.

[3] Ann. Physik, 10: 649.   1903.

[4] It is to be noted that the values given in the table are *relative* only, and are not always expressed in the same units (e g., columns c and d, e and f, h and i).

together all the data available on the elastic properties, namely, compressibility, hardness, tensile strength, elastic limit, elastic modulus, and modulus of rigidity.

From this table it is evident that as the value of $\varphi$ increases, the compressibility decreases, and the values of the other elastic properties increase steadily. The exceptions to this statement are very few as regards any one property, and vary irregularly as we pass from one property to another; in other words, there are no systematic divergences between the sequence of the metals as derived from the thermodynamic relationship discussed in this paper, and that obtained when they are arranged progressively with reference to any one of their elastic properties. The slight divergences are no greater than one might expect from the uncertain character of the thermal data, on the one hand, and of the elastic constants on the other.

From the above, then, it appears to be true that the mechanical properties of metals are correlated with the amount of pressure— assumed to act on the solid alone—requisite to cause the metal to melt at or near the ordinary temperature. This pressure in turn depends upon the melting point, the density, and the heat of melting, of the metal. The first two of these quantities are known to be periodic functions of the atomic weight, and there is every reason to believe that the heat of melting, and therefore also $\varphi$, is. Therefore we should expect some, or all, of the elastic properties to be periodic functions. So far, thoro measurements have been made only on the compressibility, which, according to Richards, shows marked periodicity.

The remarkable concordance shown in the above table, which can hardly be due to coincidence, indicates that the "flow" of metals—or indeed, every permanent distortion of a crystalline solid—is due to an actual fusion and resolidification of the crystals.

These considerations may also be used to throw light on the general behavior and properties of metals, and on many geological phenomena; but it would lead too far to go fully into these matters. We wish, however, to give briefly a mechanical picture of the probable mode of action of unequal pressure upon a metal, and to indicate how such an explanation accounts plausibly for many

of the phenomena observed in the "hardening" of metals, and for the increase of strength following upon deformation.

Le Chatelier[5] used this conception of unequal pressure to account for regelation—the consolidation of a mass of loose snow at 0° into a block of solid ice. The pressure, due to the superincumbent material, lowers the melting point at the surface of contact of adjacent grains by an amount $\Delta t$. The water formed flows out into the interstices of the snow grains, where it is at a pressure of 1 atmosphere but at a temperature of $-\Delta t$, and is in contact with ice at 0°; consequently it freezes again. This process continues until all the interstices are filled up; that is, until a solid block of ice is formed. The behavior of metals under the action of an unequal compression we conceive to be identical with that pictured above for ice. Namely, that metal melts wherever the pressure reaches the appropriate value, flows into the interstices where the pressure is smaller, and solidifies again, with the formation in general of very small crystals, owing to the exceedingly rapid rate of recrystallization. .

This mode of action, besides accounting in an approximately quantitative manner for many of the phenomena observed with metals, is also in harmony with observations on the structure of metal which has "flowed" or has been subjected to deformation of any kind.

According to Beilby[6] the process of deformation is always accompanied by a partial transformation of the metal to an "amorphous" form, which acts as a cementing material for the untransformed grains. In favor of this view, he adduces evidence that there is (a) a difference in the energy content of the strained and unstrained metal, which is manifested in a difference between the two forms, (1) in their electrolytic potential when immersed in a solution, (2) in their thermo-electric power, (3) in their heat of solution; (b) a difference in structure manifested in differences in (1) microscopic appearance, (2) mechanical properties,—hardness, tensile strength, etc., (3) density, (4)

[5] Z. physik. Chem., 9: 338.  1892.
[6] Phil. Mag. (6), 8: 258–76.  1904.

conductivity for heat or electricity, etc.    According to Faust and Tammann,[7] on the other hand, the change of properties on deformation is parallel to the formation of smaller crystallites.

Whichever be the correct interpretation—if indeed these views are mutually exclusive—the fact remains that changes in the properties of a metal ensue upon deformation, the most important one from a practical standpoint being an increase in its rigidity. The considerations presented in this paper are not inconsistent with either of the above views, and in addition, account easily for the increased rigidity of metal which has been strained. For, exactly as in the case of the consolidation of loose snow to a block of ice, as soon as the stress reaches an appropriate value (the lower elastic limit), melting and flow into the interstitial spaces take place, with immediately subsequent recrystallization; this process continues until flow is no longer possible (the upper elastic limit), whereupon increased stress produces a rupture of the material. Now, the actual process of flow diminishes the volume of the spaces into which flow is possible, and to this extent diminishes the inequality of pressure acting on liquid and solid; hence it requires progressively higher pressures absolutely (though at the same temperature the same *excess* of pressure on the solid) to produce flow; in other words, the rigidity of the material is increased.

Moreover, it is a well-known fact that the strength of eutectics (which are always fine-grained) is always greater than that of their components; further, that the varieties of steel possessing the greatest tensile strength (e.g., vanadium steels) are very fine-grained. From the standpoint of this paper, such metals are strong *because* they are fine-grained, and hence, if we wish to make a steel of high tensile strength, we should endeavor to obtain a very fine-grained structure, producing this by whatever means (addition of foreign material, heat-treatment, or mechanical treatment) may be found suitable for this purpose.

*Summary.* The object of this preliminary note is to establish the existence of a parallelism between the elastic properties of

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[7] Z. physik. Chem., **75**: 108–26. 1911.

metals and an expression—involving certain of their physical constants only—derived from thermodynamical principles on a basis which is equivalent to the assumption that the "flow," or permanent distortion, of a metal is a manifestation of an actual *melting* produced by a stress (pressure) acting on the solid phase, but not—or not to the same extent—on the liquid phase. Some of the implications of this theory are discussed briefly.

BOTANY.—*A new Echeveria from Mexico.* J. N. ROSE.

The botanical collections of the National Museum have all been greatly increased during the last few years but especially in those groups to which intensive study has been given, like the ferns, succulents, and Laciniaria. In no other group has this growth been so marked either in number of specimens or of new species as in the Crassulaceae of Mexico. In the case of these plants exhaustive and definitely directed field work has been carried on for fifteen years, while the maintenance of a large living collection has furnished good material for full and accurate diagnoses and for the making of good herbarium specimens of most of the species.

In 1880 the Crassulaceae of Mexico were catalogued by Mr. W. Botting Hemsley, who recognized 4 genera and 62 species. When the writer began his work on the group the National Herbarium contained representatives of all these genera and about 54 of the species, amounting to 86 sheets or specimens.

In 1905 Britton and Rose revised this family for the North American Flora. They recognized 17 genera and 164 species from Mexico. Since then 32 species have been described, making the total known from Mexico 196.

All these genera are represented in the collections of the National Herbarium and all the species with the exception of 8 or 10 of the older and obscure ones. The number of sheets has arisen to a total of 847. In spite of the long-continued study of this group new species are constantly coming to light, of which the following is one.

*Echeveria lutea* Rose, sp. nov.

Basal leaves numerous, ascending, thickish, 8 to 10 cm. long, light green, glabrous with upturned margins forming a deep trough, acuminate with mucronate tip, the apical portion upturned like a horn; flowering stem 20 to 30 cm. long; leaves 4 to 5 cm. long, linear, semiterete, stiff, flattened on the upper surface, pointed, with a toothed free margin at base; inflorescence a secund raceme, at first strongly reflexed but at the flowers often becoming erect; flowers 20 or more, often subsessile; sepals 5, distinct, very unequal, the longest 2 cm. long, free and toothed at base, linear, pointed, ascending; flower bud strongly 5-angled and pointed; corolla lemon yellow, 15 mm. long, the lobes distinct for about two-thirds their length but not spreading except a little at the tip.

Type in U.S. National Herbarium, no. 619743, collected at San Rafael, San Luis Potosi, Mexico, November, 1910, by C. A. Purpus and flowered in Washington, July, 1911.

This is a very remarkable species and quite distinct from all the others which we have had in cultivation. The foliage is of a rather pale green color, quite stiff, almost pungent. The flowers are a lemon yellow, an unusual color in the genus, only one other species being at all like it.
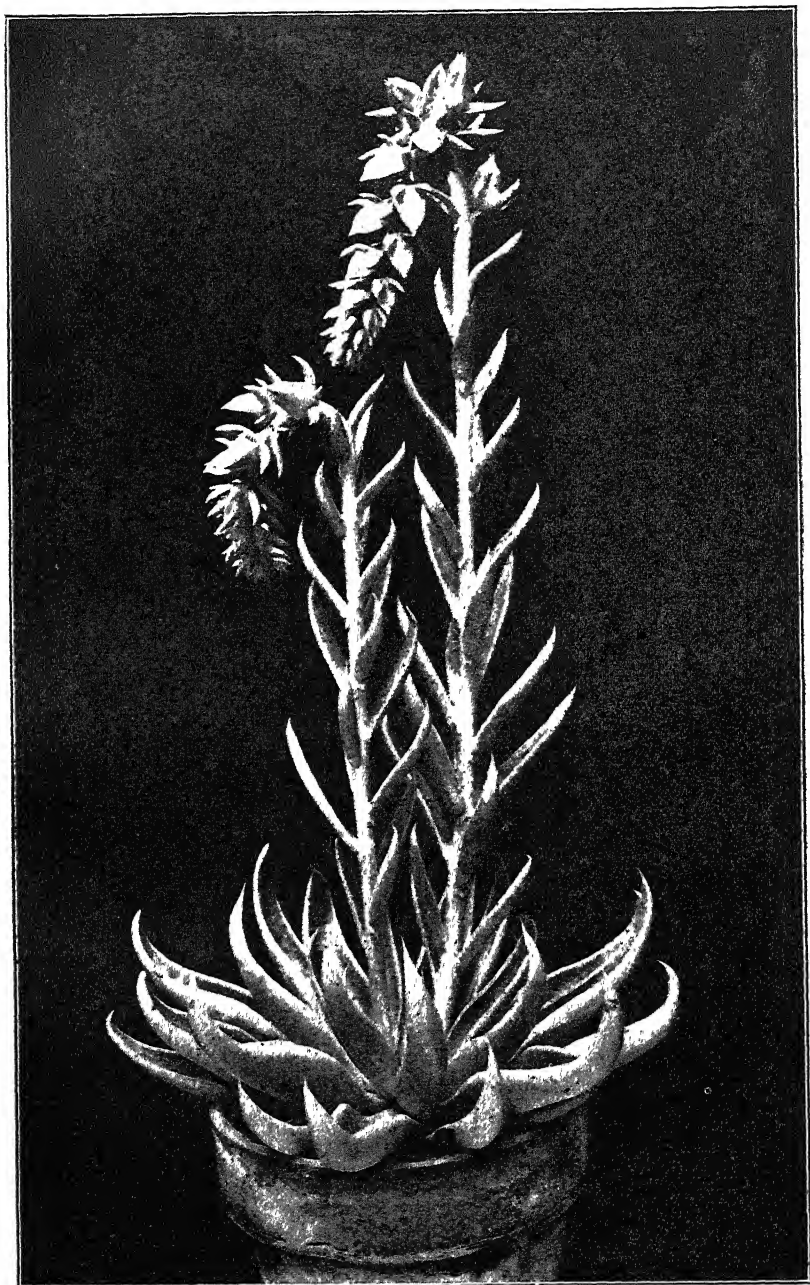
Fig. 1. *Echeveria lutea* Rose, sp. nov.

# ABSTRACTS

PHYSICS.—*The reflecting power of various metals.* W. W. COBLENTZ. Bulletin Bureau of Standards, Reprint 152. 1911.

The reflectivity of various substances is given including tungsten, tantalum, molybdenum, chromium, antimony, tellurium, vanadium, silicon, graphite, etc. The paper gives also (Note I) the thermoelectric properties of molybdenum, (Note II) a method for the preservation of silver mirrors, and (Note III) comments on radiation laws of metals (see also Bull. Bur. Standards, Reprints 45 and 105). W. W. C.

GEOLOGY.—*Mineral resources of the Llano-Burnet region, Texas, with an account of the pre-Cambrian geology.* SIDNEY PAIGE. Bulletin U. S. Geological Survey No. 450. Pp. 103, with maps, sections, and views. 1911.

The rocks of the region are: (1) pre-Cambrian schists, gneisses, and granites, (2) Paleozoic sandstones, limestone, and shales, and (3) Cretaceous sandstones, clays, and limestones.

The folded and faulted Paleozoic strata, which surround the pre-Cambrian area, are separated from the pre-Cambrian by a great unconformity. The Cretaceous formations rest almost undisturbed with pronounced unconformity on the Paleozoic rocks.

The pre-Cambrian (Algonkian?) rocks have been divided into (1) the Packsaddle schist, predominantly basic, including amphibolite and mica schists and old basic intrusive rocks; (2) the Valley Spring gneiss, including quartzites or their derivatives, light-colored mica schists, and acidic gneisses; (3) a very coarse-grained pink granite; (4) all other granitic rocks.

The granite cuts the schist as batholiths, dikes, and sills, and, in pegmatitic phase is found in minute veinlets and in huge dikes and sheets. There are all gradations between granite and schist.

In some localities the contacts between schists and dikes are sharp; at others the temperature of the intruding mass was so high that

masses of schist melted; and elsewhere granitic material forced itself between the layers of the schists and formed injection gneisses.

The iron ores are chiefly magnetite or mixtures of magnetite with hematite. The magnetite deposits typically conform with the layering of the enclosing schistose rocks, notably in the case of the leaner ore bodies.

The geologic history of the Llano ores is as follows: (1) Deposition of iron as oxide, carbonate, etc., with the sediments, either in extended basins or along borders of the sea; (2) Burial, followed by intrusion of dikes and sills of a diabasic type with possible local introduction of soda and perhaps granitic intrusions; (3) Deeper burial with subsequent folding and metamorphism and a second intrusion of basic types; (4) Intrusion by granite with great local disruption; (5) Elevation and erosion.                                        H. D. McCaskey.

ECONOMIC GEOLOGY.—*Copper deposits of the Appalachian States.* Walter Harvey Weed. Bulletin U. S. Geological Survey No. 455. Pp. 166, with 5 plates and 32 sections. 1911.

Throughout the Appalachian province the copper ores are confined to (1) crystalline schists; (2) altered basalts; (3) Triassic rocks close to trap intrusions; and (4) Devonian rocks, in which they are generally insignificant. No two deposits are precisely alike, yet if their general characteristics be considered they all fall into six types, as follows:

(1) Ducktown type. Pyrite lenses and veins in crystalline schists. (2) Copper quartz-vein type. Quartz veins containing metallic sulphides: (a) Virgilina variety; quartz veins with glance and bornite. (b) Gold Hill variety; silicified schists, containing chalcopyrite and pyrite, with ore shoots of quartz and chalcopyrite. (c) Seminole variety; zone of pyritized schists, carrying local shoots of high-grade ores. (3) Carolinian type. Bands of amphibolite traversing mica schists and carrying chalcopyrite and pyrite disseminated through the rock or gathered in bunches or, more commonly, deposited in the gray gneiss alongside. (4) New Jersey type. Impregnated shale and sandstone adjacent to trap masses; in part in the trap. (5) Pahaquarry type. Devonian sandstones impregnated with copper ores; and shales, etc., of Coal Measure regions with occasional ore; not rare, but insignificant in amount. (6) Blue Ridge (Catoctin) type. Bunches and joint fillings in the surficial portions of the basaltic rocks (Catoctin schist) of the Blue Ridge region.                                        F. L. Ransome.

ENTOMOLOGY.—*Descriptions of new species of wasps with notes on described species.* S. A. ROHWER. Proceedings U. S. National Museum, **40**: 551–587. 1911.

Forty-five new species and five new sub-species or varieties. One new genus, *Gonostigmus,* is described, and the type species is indicated for several other genera. Much of the material came from the Western States or Central America. N. BANKS.

ENTOMOLOGY. *Descriptions of six new genera and thirty-one new species of Ichneumon flies.* H. L. VIERECK. Proceedings U. S. National Museum, **40**: 173–196. 1911.

Most of the new species are from the United States, but several are from Portuguese East Africa, a few from South America, Japan, and the Hawaiian Islands.

New generic names are *Cryptoxilos,* near *Peristenus; Dolichozele,* near *Zele; Platyspathius* near *Spathius, Polystenidea* near *Hecabolus,* and *Stenopleura* near *Protapanteles.* New subgeneric names are *Dolichogenidea,* subgenus of *Apanteles;* and *Daiotes* and *Mastrus, subgenera* of *Phygadeuon;* these last two are stated to be "genera" but only used in a subgeneric sense. One or two more of Foester's names are perhaps, for the first time, connected with species. N. BANKS.

ENTOMOLOGY.—*New species of reared Ichneumon flies.* H. L. VIERECK. Proceedings U. S. National Museum, **39**: 401–408. 1911.

Descriptions of eleven new species are given and, apparently, no new generic names; nearly all were bred from insects of economic value.
.                                                                              N. BANKS.

ENTOMOLOGY.—*Descriptions of one new genus and eight new species of Ichneumon flies.* H. L. VIERECK. Proceedings U. S. National Museum, **40**: 475–480. 1911.

The new generic name, *Cyanopteridea,* is for Cyanopterus Szepligeti (not Haliday). *Parapahteles* Ashm. is made a synonym of *Apanteles.* Several of the species have been bred in connection with the work on the Gipsy moth. N. BANKS.

# PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

## THE BOTANICAL SOCIETY OF WASHINGTON

The eleventh annual meeting of the Botanical Society of Washington was held in the Bureau of Chemistry building Tuesday, October 24, 1911, President W. J. Spillman presiding.

The reports of the Secretary, Treasurer, and the Executive Committee showed that the Society is in a flourishing condition. Eight program meetings were held during the year with an average attendance of thirty-nine. Nineteen new members were added during the season, while five were lost by reason of removal from Washington and vicinity.

Officers as follows were elected for the ensuing year:

President, W. A. Orton; Vice-President, A. S. Hitchcock; Recording Secretary, Edw. C. Johnson; Corresponding Secretary, W. W. Stockberger; Treasurer, F. L. Lewton; Vice-President in the Academy of Sciences, W. R. Maxon.

At the 74th meeting of the society, at the Cosmos Club, October 10, 1911, at 8 P. M., the following papers were read: *The wilting coefficient for different plants and its indirect determination.* L. J. BRIGGS and H. L. SHANTZ. (See this Journal **1**: 228. 1911.) *The forest of Arden, a dream.* H. C. SKEELS.                    EDW. C. JOHNSON, *Secretary, pro tempore.*


# PROGRAMS AND ANNOUNCEMENTS

## WASHINGTON SOCIETY OF ENGINEERS

December 5, 8 P. M.  C. & P. Telephone Company's Hall.  Discussion of Oyster Fisheries, in which Dr. H. F. Moore, Bureau of Fisheries, Dr. Caswell Grave, Scientific Member of the Maryland Shellfish Commission, and Mr. C. C. Yates, of the Coast and Geodetic Survey, will participate.

December 19, 8 P. M.  Cosmos Club Hall.  Annual meeting and election of officers.  Mr. George W. Littlehales will give a paper on the relation of the engineer to the advance of civilization.

## PHILOSOPHICAL SOCIETY

701st Meeting and 41st Annual Meeting.  December 9, 1911.  Cosmos Club at 8.15.  Reports and election of officers.

RADIO-TELEGRAPHY.—*A ship's antenna as a Hertzian oscillator.* L. W. Austin, Naval Wireless Telegraphic Laboratory.

In the work on long distance radio-telegraphy[1] it was shown that the equation giving the value of the current in the receiving antenna in terms of the sending antenna current, the antenna heights, the wave length, and the distance was identical in form with the Hertzian equation for the amplitude of the electric waves at a distance from the oscillator, provided this distance was not great enough to involve the atmospheric absorption.

I have made a calculation of the current which might be expected in a receiving antenna, making use of the form of radiation formula given by Zenneck.[2]

$$E = 2\pi \frac{l}{\lambda} \frac{J}{d} \, 3 \cdot 10^{10} \text{ c.g.s.}$$

Here $l$ represents the length of the oscillator, $\lambda$ the wave length, $J$ the current and $d$ the distance in the equatorial plane from the oscillator. The difficulty in applying the equation to the case of the scout cruisers *Birmingham* and *Salem* lies in the determination of the dimensions of the electrical oscillator which would be equivalent to the antenna system of the ships. Considering the antenna as forming half the oscillator, the lower half of which may be imagined to be below the surface of the sea, $l$ would be equal to $2h$ where $h$ is the height to the center of capacity of the antenna. But, since the lower half of the antenna contributes

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[1] Bull. Bur. Standards, **7**: 315. 1911.

[2] Zenneck, Leitfaden der Drahtlosen Telegraphie, p. 43.

nothing to the radiation, the Hertzian oscillator which will radiate the same amount of energy as the antenna will be[3] $\sqrt{2} \cdot h$. In our case, however, this does not fully determine the value of $l$, since the wireless room is some 30 feet above the water and enclosed in the steel hull which is at approximately zero potential. Then too, the exact height of the center of capacity of the antenna system is a matter of some uncertainty. Since the lines of electric force to a large extent come down to the water and not to the hull, it is probable that the point where the antenna leaves the hull at the wireless room is somewhat too high to be taken as the center of the oscillator. On the other hand, the center of capacity of the antenna is certainly lower than the level of the flat top antenna. As a probable approximation I have taken the height from the wireless room to the antenna top, 29.2 meters as the value of $h$. Then $l = 41.3\ m$, $\lambda = 1000\ m$, the average sending current of the two ships, $J = 30$ amperes. Then in c.g.s. units.

$$E = 6.28 \frac{4 \cdot 13 \cdot 10^3}{1.10^5} \frac{3}{1.10^5}\ 3 \cdot 10^{10} = 2.34 \cdot 10^5 \text{ c.g.s.} = 2.34 \cdot 10^{-3} \text{ volts per centimeter}$$

* The receiving electromotive force on the antenna will be $E \cdot h = 2.34 \cdot 10^{-3} \times 2.92 \cdot 10^3 = 6.83$ volts. The resistance of the receiving antenna was approximately 25 ohms, thus,

$$\text{Calculated Received Current} = \frac{6.83}{25} = 0.27 \text{ amperes}$$

The corresponding observed value, that is the average of the two values of $K$ in Tables X and XI of the paper already cited, gives

$$\text{Observed Received Current} = 0.21 \text{ amperes.}$$

Considering the difficulties in determining the values of $h$ and the fact that a certain portion of the radiated energy must have and the fact that a certain portion of the radiated energy must have been absorbed by the rigging of the ships, the agreement between the calculated and observed currents seems quite as good as it is possible to expect.

[3] R. Ruedenberg Ann. d. Phys. 25: 446. 1908.

ELECTRICITY.—*The capacity and phase difference of paraffined paper condensers as functions of the temperature and frequency.* FREDERICK W. GROVER. Communicated by E. B. Rosa. To appear in the Bulletin of the Bureau of Standards, 7: No. 4. 1911.

In an ideal condenser the capacity would be independent of changes in the temperature and the frequency of the measuring current, and the phase of the current thru the condenser would always be 90° ahead of that of the electromotive force impressed on the condenser. In actual condensers these conditions are not exactly fulfilled; the capacity decreases somewhat with increasing frequency and the temperature coefficient of the capacity is appreciable. Further, the phase of the current lags behind the ideal position of 90° in advance of the electromotive force, by an angle $\theta$, which is usually small but always measurable. (In what follows the angle $\theta$ will be designated as the *phase difference*.)

To account for these departures from the behavior of an ideal condenser, all of which have their origin in the phenomenon of electric absorption, a number of theories have been proposed which give at least a *qualitative* explanation of the facts. Much of the existing experimental data, has, however, been obtained from experiments with a steady applied voltage, and with such various times of charge and discharge, lengths of insulation or short circuit, and such different galvanometer periods, as to render it very difficult, if not impossible, to decide whether or not there is *quantitative* agreement between any given theory and the observations. To meet this difficulty, measurements with alternating currents would appear to be especially suitable to give data for such comparisons, since the condenser is submitted to a perfectly definite cycle of charging and discharging.

The present paper gives the results of measurements of the capacity and phase difference of thirteen commercial condensers by English, French, German and American firms at temperature ranging from 10° to 35° in steps of 5°, and at frequencies of from 33 to 1000 cycles per second. In every condenser, the dielectric

was of paraffined paper, except in two cases; where paper impregnated in beeswax was employed.   Such condensers were selected, on account of their relatively large and varied absorption effects, as being better fitted for a theoretical study of absorption than mica condensers.

The measurements were made by means of alternating current bridge methods in use at the Bureau of Standards,[1] using as indicating instruments vibration galvanometers, tuned to the frequencies of the currents used.   This procedure has the advantage, that the balance of the bridge depends on the fundamental component only of the electromotive force wave employed, thus rendering valid in the theoretical work, the assumption of a sinusoidal electromotive force.   The condensers were compared, by substitution, with standard mica condensers whose constants were known from previous work, and capacity effects between the different parts of the bridge and the earth were shown to have no influence on the results thus obtained.

The following points of practical importance were established by the measurements:

1.   The temperature coefficients of the capacity of those condensers with the smaller values of the phase difference (5′ to 20′), were found to be negative and nearly constant, 2 to 6 in 10,000, except at the higher temperatures.   This effect is to be ascribed to the expansion of the paraffin, the actual effect of absorption being of relatively small importance, except in those condensers of larger phase difference.   In the latter case the temperature coefficient of the capacity is positive and increases rapidly with the temperature, reaching in some instances, values of the order of one per cent per degree.

2.   In all cases, the capacity decreases with increasing frequency, at first rapidly and then more slowly, the changes being the larger, at all frequencies, in condensers with the larger phase differences.

3.   While the phase difference of a mica condenser is usually less than 3′ or 4′ and often is as small as 30″ at 1000 cycles, the

[1] Bull. Bureau of Standards, 3: 371.   1907.

paper condensers here studied, in no case gave values less than 6', and in the case of the poorer condensers the phase difference ranged from 1° to the enormous value of 22°. It was found that in the case of some telephone condensers, made by rolling up together long strips of tin foil and paraffined paper, the energy loss, in the resistance of the tin foil, amounted to considerably more than the loss in the dielectric. (This disadvantage may be avoided by making connection to the tin foil at several points along its length).

4. The phase difference generally increases with increasing temperatures; and in those condensers with large phase difference, the rate of increase becomes rapidly larger with rising temperature.

5. The phase difference, when corrected for the resistance of the plates and leads, decreases with increasing frequency, at first rapidly and then more slowly. The rate of change is greatest, at all frequencies, in the case of condensers with large phase difference.

6. The capacity of a paper condenser varies so considerably with the conditions under which it is used, that such a condenser should not be employed in work where a knowledge of the capacity is requisite, except where a previous study of the condenser has shown that it may so be used.

In the latter half of the paper, the absorption theories of Maxwell,[2] Houllevigue,[3] Pellat,[4] von Schweidler[5] and Hopkinson[6] are considered for a sinusoidal wave of electromotive force, and the formulas for the capacity and phase difference, as functions of the frequency, are compared with the observed results. The theory of von Schweidler (which is a modification of the Pellat theory and its mathematical equivalent, that of Hopkinson) assumes that the absorption in a dielectric is due to the presence of a periodically damped ions and the capacity and phase differ-

[2] Elect. and Magnet., I, § 330.

[3] Jour. de Phys., 6: 113. 1897.

[4] Ann. de Chim. et Phys. 18: 150. 1899.

[5] Ann. der Phys., 24: 787. 1907.

[6] Phil. Trans., 167: 599. 1877.

ence depend on the number and the distribution of these abnormal ions as a function of their rate of damping.

It is further shown that only a few constants need be determined in von Schweidler's equations to represent the observations with a good degree of accuracy. The remaining theories do not seem to be adequate to represent the present observations.

FISHERIES.—*Notes on the breeding season and young of Polyodon spathula.* WM. F. ALLEN, Institute of Anatomy of the University of Minnesota.

Since the appearance of Mr. Allis's recent papers in the Anatomischer Anzeiger on the "Pseudobranchial and carotid arteries of *Polyodon*" in which he made use of a specimen 130 mm. (5.5 inches) long, I have received several letters of inquiry as to when and where this material was obtained.

It is a well-known fact that nothing is known concerning the early development of *Polyodon*, and very few specimens under 6 inches in length have been obtained.

In 1904, when employed by Mr. Allis, I was sent to the Mississippi River for the purpose of obtaining all of the Ganoid material possible. After considering various localities on the Mississippi River system, the junction of the Ohio with the Mississippi, at Cairo, was selected as probably the most favorable place for obtaining this material.

For an entire year the bars of these rivers were seined at all times of the day and night; also the adjacent overflow lakes, sloughs, and small streams were seined at regular intervals thruout the year, and during the early spring a number of adults were obtained from hoop-nets placed in the channel on the Missouri side of the Mississippi, with the hope of obtaining sexually mature individuals whose eggs could be fertilized and the embryos reared.

So far as early embryonic material was concerned my results were a failure, but a great many specimens from 6 to 12 inches long were obtained, and about 25, varying in length from 4 to 6 inches were secured. Considerable data were obtained concerning the habits that may be of value in future search for this material.

*Spawning Season.*—In this locality the spawning of this species occurs during the month of March, mainly from the first to the middle of the month. I have never seen sexually mature *Polyodon* weighing less than 15 or 20 pounds and fish of this size are rarely, if ever, taken by seining the sand and mud bars of the rivers; they can, however, be obtained from the deep channel on the Missouri side of the Mississippi, from Bird Point south, by the use of hoop-nets. Floating ice prevented this mode of fishing for the first week of March, 1904, but during the second week, three mature females and several spent females were taken from these nets, but no males. One of these females was tied out from a fish wharf by a stout string attached to its tail, and the other two were placed in a fish cage anchored to the wharf, with the hope of keeping all three alive until a mature male could be secured, but with the result that the one tied out with a string was stolen and the two in the fish cage lived but four or five days, dying doubtless from injuries received in vain attempts to escape. Upon examining the eggs they appeared mature, were black in color, and very closely resembled the eggs of *Acipenser* and *Lepisosteus*. During the third week in March a single mature male was obtained along with several spent females. I am unable to account for the scarcity of males during the breeding season.

From this time on most vigorous efforts were made to secure the young of *Polyodon* by seining the small streams, sloughs, overflow lakes, and the sand and mud bars of the two rivers with a fine meshed seine, but not until July first were any located, when some 25 specimens of from 4 to 6 inches in length were caught from Minor Slough. This slough is located on the Kentucky side, at the junction of the Ohio with the Mississippi. It had been seined numerous times before this; in fact, the very day before, but always with negative results. The previous day (June 30) marked a high water stage of the rivers, and on July first the rivers were beginning to recede rapidly, so that there was a strong current in the outlet of the slough. The small *Polyodon* obtained doubtless migrated from the river during the previous night or early morning, when the water in the outlet could have

been almost at a standstill or a rather strong current.    There is no ground whatever for believing that these little *Polyodon* were hatched and reared in Minor Slough.

While this seining was being done a violent thunder storm was in progress so that little time was spent in examination of these most interesting specimens; they were immediately thrown into a fixing fluid.    It was noted, however, that their bill or paddle constituted about one-half of their total length, and that their bodies were almost transparent.

Notwithstanding that this slough and other overflow lakes and small tributary streams were afterward frequently seined with a fine-meshed seine, and the river bars were seined with both fine- and coarse-meshed seines, during both day and night, no other young *Polyodon* were found until late in August or early September, when a large number were obtained thru seining, at night or early morning, the mud and sand bars of the Ohio River opposite Cairo on the Kentucky side.    Singular to say, they were never obtained in this manner during the day time.    Apparently they never leave the channel except at night to feed in the mud and sand bars.    These small fish were all obtained by the use of a very long coarse-meshed seine.    It is possible that if a sufficiently long fine-meshed seine could have been operated on the river bars at night, or dragged on the bottom of the channel during the day, still younger stages would have been obtained.

My experience with *Polyodon* leads me to believe that it is primarily a deep-channel fish, that the eggs are laid and the young are reared in the deep channel rather than in the shallow water of the river, or in overflow lakes, or in small tributary streams; that the young do not leave the main channel to feed in the mud bars of the river or the sloughs until they have attained a length of 3 or 4 inches.    About Cairo, Illinois the spawning season occurs during the month of March, and only specimens from 15 to 20 pounds and up are sexually mature.    Fish of this size are rarely, if ever, taken in seining the river bars, but they can be had in small numbers from fishermen operating hoop-nets in the Missouri channel of the Mississippi south of Bird's Point.

# ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

ELECTRICITY.—*Outline of design of deflection potentiometers, with notes on the design of moving-coil galvanometers.* H. B. BROOKS. Bulletin Bureau of Standards 8: No. 2. 1911.

This paper outlines the principles on which deflection potentiometers are designed, and gives a numerical example. It includes some notes on the fundamental constants of the moving-coil galvanometer, and shows how to change the field strength, spring strength and size of wire in order to secure a desired galvanometer performance. A procedure is outlined which is intended to facilitate the production in quantity of galvanometers whose resultant performance is satisfactory, while allowing some latitude in the values of individual constants. H. B. B.

ELECTRICITY.—*Deflection potentiometers for current and voltage measurements.* H. B. BROOKS. Bulletin Bureau of Standards, 8: No. 2. 1911.

The deflection potentiometer differs from the usual potentiometers in one essential feature, viz., the use which it makes of the galvanometer. The greater portion of the electromotive force under observation is compensated, but the galvanometer deflection indicates the remainder. The accuracy obtainable by the potentiometer method is thus combined with the ease and speed of reading a deflection. In previous papers (Bulletin of Bureau of Standards, 2: 225. 1906, and 4: 275 1908) the writer has described two forms of deflection potentiometer, both intended for voltage measurements only. This paper describes two new instruments, each of which is suitable for both current and voltage measurements. The theory of the deflection potentiometer used with current shunts is developed, and a special set of values for such shunts is shown to give economy of time in testing, with reduced computation and liability of error. J. H. DELLINGER.

PHYSICS.—*High-temperature gas thermometry*. ARTHUR L. DAY and
ROBERT B. SOSMAN; with an investigation of the metals by E. T.
ALLEN, Geophysical Laboratory. Publication No. 157, Carnegie
Institution of Washington.

The errors which have heretofore been present in measurements with
the nitrogen thermometer have been reduced by the present investiga-
tion to about one-fourth their former magnitude, and the certainty of
their evaluation is at least proportionately increased.

The particular points to which most attention has been given are the
following:

(1) To provide a uniform temperature about the bulb by a suitable
arrangement of electric-heating coils and diaphragms.

(2) To enclose the furnace in a gas-tight bomb in which the pressure
outside the bulb can be maintained equal to that within for all tempera-
tures. This offers three distinct advantages: (*a*) it provides against
the deformation of the bulb through differences of pressure within and
without in the region of highest temperatures, where the bulb material
becomes softer; (*b*) by using the same gas within and without, there is
no tendency for it to diffuse through the bulb wall; (*c*) it enables the
initial pressure to be varied within considerable limits, thereby increas-
ing both the scope and sensitiveness of the manometer.

(3) The expansion of the bulb material was determined with great
care and is probably accurate within 0.5 per cent.

(4) The unheated space between the bulb and manometer has been
reduced until the total correction in this hitherto uncertain region
amounts to less than 4° at 1100°. An error of 5 per cent in the deter-
mination of its volume or temperature distribution is, therefore, prac-
tically negligible.

It is probable that these changes serve to reduce the uncertainty
hitherto prevailing in the correction factors which require to be applied
to the gas thermometer in the region of 1100° to less than one-tenth of
its former magnitude. Furthermore, these improvements are equally
applicable throughout the region above 1100° as far as the present
measurements have extended (to 1550°). The chief source of the present
uncertainty is the temperature distribution over the surface of the
bulb in an air-bath.

No effort has been made to prepare metals of exceptional purity in our
own laboratory, for the reason that such metals would not be available
for general use and would therefore be of little service. We have accord-
ingly adopted metals which are carried permanently in stock by dealers.

In order to facilitate as far as possible the application of these results

in general practice, a typical thermo-element curve has been tabulated in small 10° intervals thruout its entire length from melting ice to melting platinum, together with a diagram showing the character and magnitude of the variation from this curve which may be expected to appear in other thermo-elements of the same nominal composition (90 parts platinum, 10 parts rhodium). With a new platin rhodium thermo-element of undoubted homogeneity, but unknown constants, it is quite practicable with this table to prepare a curve of its electromotive force for any temperature with sufficient accuracy for most purposes (say 5° at low temperatures and $\doteq$ 10° above 1200°) from a single determination in melting copper.

LIST OF STANDARD MELTING POINTS

| SUBSTANCE | POINT | ATMOSPHERE | CRUCIBLE | TEMPERATURE | HIGH-BANSTAIT SCALE |
|---|---|---|---|---|---|
| | | | | ° | ° |
| Zinc . | Melting and freezing | Air | Graphite | 418 2 $\doteq$ 0 3 | 419 0 |
| Antimony | Melting and freezing | Carbon monoxide | Graphite | 629 2 $\doteq$ 0 5 | 630 . |
| Silver | Melting and freezing | Carbon monoxide | Graphite | 960.0 $\doteq$ 0 7 | 961 5 |
| Gold | Melting and freezing | Carbon monoxide | Graphite | 1062 4 $\doteq$ 0 8 | 1064 0 |
| Copper .. | Melting and freezing | Carbon monoxide | Graphite | 1082 6 $\doteq$ 0 8 | 1084 1 |
| Diopside (pure) | Melting | Air | Platinum | 1391 3 $\doteq$ 1 5 | |
| Nickel . | Melting and freezing | Hydrogen and nitrogen | Magnesia and magnesium aluminate | 1452 3 $\doteq$ 2 0 | |
| Cobalt.. | Melting and freezing | Hydrogen and nitrogen | Magnesia | 1489 8 $\doteq$ 2 0 | 1575 1 |
| Palladium | Melting and freezing | Air | Pure magnesia | 1549 2 $\doteq$ 2.0 | |
| Anorthite | Melting | Air | Platinum | 1549.5 $\doteq$ 2 0 | |

There is no sure way to guard against the contaminating influence of metal-vapors upon a thermo-element in laboratory or industrial practice, altho glazed porcelain is usually effective.    There are very simple and rapid means of detecting contamination in an element and determining its distribution, and with a second element at hand for an occasional comparison there is little of serious danger from this cause.    In any case, the slight inconvenience is well worth while wherever considerable accuracy is sought, for there is no other device yet available, in the region between 1100° and 1600°, which is comparable with the thermo-element in sensitiveness and general practicability.

In conclusion, the list of standard melting-points is given in tabular form, together with an estimate of the degree of trustworthiness to be accorded to each.    Beside it for convenient comparison is the present Reichsanstalt scale.    It may be added that no indication of a limit to the temperature attainable with the nitrogen thermometer or to its ultimate accuracy was discovered during the present investigation.

In addition the following temperatures were incidentally obtained:

| SUBSTANCE | POINT | ATMOSPHERE | CRUCIBLE | TEMPERATURE | REICH-SANSTALT SCALE |
|---|---|---|---|---|---|
| | | | | ° | ° |
| Cadmium.. | Melting and freezing | Air | Graphite | 320 0 ±0 3 | 321 7 |
| Aluminum | Freezing | Carbon monoxide | Graphite | 658.0 ±0 6 | 657 |
| Li₂SiO₃.... | Melting | Air | Platinum | 1201    ±1 | |
| Platinum . | Melting | Air | | 1752 | |
| | | | | 1755    ±5 | |

A. L. D and R. B. S.

ECONOMIC GEOLOGY.—*The production of asbestos in 1910.*    J. S. DILLER.    Advance chapter from Mineral Resources of the United States for 1910, pp. 1–13.    *The types, modes of occurrence and important deposits of asbestos in the United States.*    J. S. DILLER.    U. S. Geological Survey Bull., 470-K, pp. 3–22, with 2 maps.    1911.

The annual production of asbestos for 1910 in the United States was 3,693 tons, about one-twentieth as much as that of Canada whose output for the same time was 75,578 tons, which is 78 per cent of the total production of all countries.    Georgia and Vermont are the chief producers

in the United States, but Arizona, Idaho, Virginia and Wyoming have deposits of special interest.

The fundamental property of asbestos is its fibrous structure, and it includes the fibrous forms of several species of minerals, especially amphibole and serpentine.

Using the term "type of asbestos" to designate the form of fibrous aggregation and "mode of occurrence" to designate the environment of the asbestos deposit, referring especially to its relation to the rocks with which it is genetically associated, there are three types of asbestos and four modes of occurrence known in the United States.

The three types of asbestos are cross fiber, slip fiber, and mass fiber. The first occurs in veins and the fibers, if not disturbed since their formation, run across the veins. The second occurs along planes of rock fractures on which slipping has occurred, and the direction of the parallel fibers in the slipping plane indicates the direction of the slipping. The third occurs in the form of bundles or groups and the fibers may be parallel or divergent. It is strongly contrasted with cross fiber and slip fiber in that it forms the whole mass of the rock in which it is developed.

Asbestos of the cross fiber type is almost invariably chrysotile (serpentine) and rarely anthophyllite. Some of the slip fiber type is chrysotile but more is amphibole. The mass fiber type, so far as known, is always anthophyllite in the United States.

The first mode of occurrence is illustrated by the mines at Chrysotile, in the Lowell region of Vermont, where the productive serpentine belt, so extensively mined in eastern Canada, reaches the United States. There is a similar but less productive locality near Casper, Wyoming.

An excellent illustration of the second mode of occurrence is in the Grand Canyon of the Colorado in Arizona, where veins of high-grade cross fiber chrysotile occur in a narrow belt of limestone. The limited quantity and difficult accessibility hinders mining in that region.

The third mode of occurrence as mass fiber (anthophyllite) is well illustrated at Sall Mountain, Georgia, where though much less valuable than chrysotile it has been mined for many years. There is a similar deposit at Kamiah, Idaho.

The fourth is illustrated by the slip fiber veins in the hornblendic and pyroxenic rocks of Bedford City and Rocky Mount, Va., where unsuccessful attempts to mine it were made some years ago.     J. S. D.

HYDRAULICS.—*Measurements of the suction of vessels made in the experimental model basin at the Navy Yard, Washington, D. C.* U. S. Hydrographic Office Pilot Chart of the North Atlantic Ocean for June, 1911.

Naval Constructor D. W. Taylor has recently investigated the question of the relative reactions of vessels under way and close to one another. These reactions are found to be strong, and the suction due to them when vessels make ill-advised attempts to pass others too closely account for many collisions especially in shallow waters.

The models, which were of a mean immersed length of 20 feet and of a displacement of 3000 pounds, were towed in pairs abreast, or at definite distances ahead or astern. In the abreast positions, they were towed at various distances apart; for other positions, the uniform distance apart of their center lines was nineteenth-hundredths of the length of the model. While this is quite close, it should be remembered that these experiments were made in water many times deeper than the draught of the models, and hence the suction effects under given conditions would be less than if the water had been relatively shallow, as is usually the case when suction phenomena are of importance in connection with actual ships. Imagine one vessel overtaking another on a parallel line, quite close to the right of the latter, then the sequence of phenomena is about as follows:

When the overtaking vessel just begins to overlap the other, there is little force acting. There appears to be a repulsion at both bow and stern, and curiously enough the repelling force upon the stern appears to be greater than that upon the bow. The resulting tendency is for the overtaking vessel to turn in toward the overtaken vessel. When partially overlapping, the tendency is for the bow to be drawn in while the stern is still repelled.

As the overtaking vessel continues to pull up, the suction at the bow becomes stronger and the repulsion of the stern falls off, until, as they come abreast, there is a rapid change in the stern force, which shifts from repulsion to strong suction.

As the overtaking vessel draws ahead, there is a reversal of conditions, the bow pull falling off rapidly, and soon becoming a repulsion, while the stern pull becomes stronger, reaching its maximum when the center of the overtaking vessel is about two-tenths its length ahead the center of the overtaken vessel. It should be understood that the idea of the right hand vessel overtaking the other is simply used for convenience in description. For given relative positions, the forces upon the right-hand vessel would be the same whether overtaking or overtaken.

In close quarters the intensity of these reactions may amount to twice the resistance of the vessel to propulsion, and situations may readily arise in which vessels will be brought into collision regardless of the action of the rudder. G. W. LITTLEHALES.

FISHERIES.—*Special investigation of the Alaska fur-seal rookeries, 1910.* HAROLD HEATH. Bureau of Fisheries Document No. 748. Pp. 22. November, 1911.

Dr. Heath, sent to the Pribilof Islands as a special scientific investigator pending the permanent appointment of a resident naturalist under the act of Congress of April 21, 1910, affecting the seal fisheries, reports that compared with estimates of the preceding year the herd has apparently undergone a loss of 13,293 in its numbers, by reason of the incessant killing of seals at sea in the vicinity of the islands by the Japanese and Canadian fleets.

The breeding herd is well supplied with male life, however, the average harem in 1910 containing fewer than 32 cows and there being a surplus of 600 idle and young bulls. With such proportions of the sexes and the polygamous habit of the seal, and with, moreover, a breeding reserve of 1,000 to 2,000 bachelors exempted from killing every year, there is no possibility of injury to the seal herd as a result of land killing under present regulations. ETHEL M. SMITH.

FISHERIES.—*The salmon fisheries of the Pacific coast.* JOHN N. COBB. Bureau of Fisheries Document No. 751. Pp. 179. November, 1911.

This report is historical, descriptive and statistical, covering the entire period of salmon canning on the west coast, discussing the development of fishing methods and preservation processes, and containing figures for every year from the beginning of the industry down thru 1909. It contains also a chapter on fishery legislation and law enforcement, an account of salmon hatchery work, and figures showing the foreign trade in salmon. E. M. SMITH.

FISHERIES.—*The fur-seal fisheries of Alaska in 1910.* WALTER I. LEMBKEY. Bureau of Fisheries Document No. 749. Pp. 35. November, 1911.

The status of the fur-seal industry of Alaska was changed by the law of April 21, 1910, the former leasing system being abandoned for direct government management of these resources.

The law relating to the killing of seals on the Pribilof Islands exempts all females and all seals under one year of age. The additional Depart-

ment regulations, similar in 1910 to the regulations of previous years, restricted the killing further to bachelors having pelts weighing at least 5 pounds and not more than $8\frac{1}{2}$ pounds, except such as might be required to complete the natives' supply of food. Before any killing was done 1,271 bachelors, 915 of them three-year-olds, were marked and exempted as a breeding reserve. The take of skins was 13,584.

Mr. Lembkey's estimate of the number of seals in the herd in 1910 at the end of the killing season is 132,279. This is approximately the same as Dr. Heath's estimate of 149,195, the latter figure including the 13,584 that were killed.

Mr. Lembkey urges the continued killing of surplus male seals, not only to permit the government an income from the seal resources but to preserve the herd from the injurious presence of the haremless and fighting bulls. He urges also a readjustment of the scheme of compensation for the natives, abolishing the government contribution as such and paying higher wages.                               E. M. SMITH.

PLANT PATHOLOGY.—*The timber rot caused by Leniztes sepiaria.* PERLEY SPAULDING, Bureau of Plant Industry, Bulletin 214, Pp. 46. July 21, 1911.

*Lenzites sepiaria* is one of the most important of the fungi which destroy coniferous timber while in use. It does not ordinarily attack living trees. With several other species it destroys a large proportion of the coniferous railway ties and telegraph and telephone poles which are in service in this country. The fungus is very widely distributed and attacks the wood of spruce, larch, fir, pine, hemlock, Douglas fir, and juniper, and occasionally attacks the wood of willow and aspen. It usually enters timbers through season cracks. The fruiting bodies revive after long periods of desiccation, the writer having obtained spores from specimens after two years' time. Mature sporophores may be produced within six or ten days after the first mycelium becomes visible on the exterior of an affected timber. Inoculations in green timber have produced sporophores within five months' time in Texas. Pure cultures have been made and the same type of rot has been secured upon sertilized wood blocks in large tubes as that which commonly accompanies the fruiting bodies in the open air. The decay caused by this fungus may be prevented or greatly retarded by seasoning of timber, which decreases the water content to such a point that the fungus cannot readily grow; by floating, which largely excludes the air; and by chemical treatment with substances which are poisonous to the fungus.                               P. S.

# PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

## THE BIOLOGICAL SOCIETY OF WASHINGTON

The 486th regular meeting was held at the Cosmos Club, October 21, 1911, President David White in the chair, and about 60 persons present.

The principal communication was presented by O. P. HAY, of the U. S. National Museum on *The Ice Age and its Animals,* illustrated by lantern slides, showing maps of the areas of successive glaciation and photographs of the characteristic fossils as well as restorations of the mammals.

The 487th regular meeting was held November 4, 1911, the president in the chair and about 75 persons present.

Under the heading *Brief Notes and Exhibition of Specimens,* W. P. HAY exhibited lantern slides from photographs of living *Amphioxus,* and of the blue crab, with egg masses. He calculated the number of eggs laid by the female of this species as about 1,500,000.

The regular communication was on *Recent Biological Explorations in Panama,* participated in by S. E. MEEK, E. A. SCHWARTZ, E. A. GOLD-MAN, and AUGUST BUSCK.

In the fall of 1910 the Smithsonian Institution perfected plans for a somewhat comprehensive and thoro biological survey of the Panama Canal Zone. It was realized that the solution of a number of vital problems in the geographic distribution and origin of the fauna and the flora of that region requires thoro field investigations in the Zone and adjacent territory before the great physiographic changes occur which will come with the completion of the Canal. It was therefore felt that the necessary field work should be undertaken at once. With this object in view Dr. Charles D. Walcott, Secretary of the Smithsonian Institution, invited the various scientific bureaus of the government to coöperate with the Institution in making such a survey. The Bureau of Fisheries and the Field Museum of Natural History, having already contemplated making such a study of the aquatic life of the Zone, promptly joined the Smithsonian, and the entire work was carried on under the general direction of that Institution.

The Bureaus and institutions participating in the survey are as follows: The Smithsonian Institution; the Field Museum of Natural History; the Bureau of Fisheries; the Biological Survey; the Bureau of Plant Industry, and the Bureau of Entomology.

At this meeting Dr. E. A. Schwartz and Mr. August Busck of the Bureau of Entomology told of the entomological work done by the recent

expedition to the Canal Zone. The work of former collectors of insects in the region was reviewed as well as that done during the present year. The climatic conditions were described and their effect on the insect fauna was considered. The operations incident to digging the Canal have destroyed much of this fauna in the immediate vicinity of the work. In spite of efforts to destroy them, a few flies and mosquitoes still exist.

Dr. S. E. Meek of the Field Museum spoke of the fishes and other aquatic life of the Canal Zone and showed maps and a series of pictures of characteristic scenery along the streams in which collecting was done, as well as of operations along the Canal route. In Dr. Meek's field work he was assisted by Mr. S. F. Hildebrand of the Bureau of Fisheries. They landed at Cristobal, December 28, and at once entered upon their field investigations which they continued without interruption until the twenty-fourth of the following May. They gave first attention to those streams soon to be most changed by the work on the Canal. Then collecting was done in the brackish waters and along the shores in order that ample series of specimens might be gotten of those species most likely to pass through the Canal on its completion. Practically all the streams of the Zone and a few adjacent ones on the Pacific side were thoroly explored. Much additional work remains to be done in the salt and brackish waters, particularly on the Atlantic side, and in the streams in the adjacent territory.

It is necessary to extend the explorations to the streams and shallow bays on each side of the Zone for a distance of 50 to 100 miles. It is the intention to do this during the coming winter.

Mr. E. A. Goldman of the Biological Survey told of his field work in studying the distribution and abundance of the mammals and birds, and collecting specimens. He remained in the field from December 28 to the end of June following. Gatun was selected as headquarters, as that region will undergo great biologic changes as a result of the transformation of a forest into a lake with an area of 164 square miles upon the completion of the Canal. Nearly 2500 specimens were secured. Among bird groups the antthrushes, flycatchers, woodhewers and hummers are most numerous in genera and species. Mammals of 39 genera, exclusive of bats, were collected. These included five genera of monkeys and four generations of opossums. One of the most interesting of the mammals collected is a specimen of *Bassariscyon*, one of the rarest of American mammals in the museums of the world. The genus has a known range extending from Nicaragua on the north to Ecuador on the south, and while it includes four species probably less than 10 individuals, all told, have been collected.

While the work was concentrated largely in the Gatun Lake area collections were also made at various localities along the line of the Panama Railroad southward to the Pacific coast, and in adjoining parts of Panama. In March a trip was made overland from Chepo into the mountains near the headwaters of the Chagres River where ten days were spent on the Cerro Azul, a mountain about 3000 feet high. To reach this mountain pack horses were used to transport the field outfit

across the broad, open savannas which extend from the Pacific coast to the base of the mountain, where the loads were transferred to the backs of men. At this point the heavy forest begins abruptly and extends upward in unbroken growth, becoming lower, but denser, until on the summit where the rainfall is more copious, orchids and bromeliaceous plants overspread the ground as well as the branches of the trees. In the latter part of May work was carried on at Porto Bello, on the north coast, and by traversing swamps and wading eight or ten miles up the Cascajal River the upper slopes of the Cerro Brujo were reached at about 2000 feet altitude       D. E. LANTZ, *Recording Secretary.*

## THE GEOLOGICAL SOCIETY OF WASHINGTON

The 245th meeting was held at the Cosmos Club, May 10, 1911. As an informal communication Mr. L. D. BURLING exhibited specimens of Silurian crinoid stems associated with Pleistocene mollusks collected on the beach north of Chicago. Both are well preserved and afford an example of mechanical mixture of faunas of widely different age.

### REGULAR PROGRAM

*The anorthite-nephelite series.* N. L. BOWEN.
*The classification of higher grade coals.* G. C. MARTIN.
*On the classification of ore deposits.* WALDEMAR LINDGREN.

At the 246th meeting, May 24, Mr. E. W. SHAW presented two new facts concerning the Maquoketa formation of the Upper Mississippi lead and zinc district: (1) Certain more or less round bits of rock resembling concretions with obscure structure and found in a layer near the base of the formation are fossil algal secretions.    (2) There is a heretofore undescribed angular unconformity between the Ordovician and Silurian at the top of the Maquoketa shale, and a non-fossiliferous rock which has been considered to be Maquoketa is in reality Silurian resting upon the thin parts of the Maquoketa. The Marquoketa, instead of being 200 feet thick as stated in published reports, varies from 180 to less than 100 feet. At the base of the non-fossiliferous rock and resting upon the deeply eroded Maquoketa is a thin layer appearing to be laminated sandstone but made up of grains of dolomite.

By invitation of the Council Prof. JOHN C. MERRIAM of the University of California spoke on recent progress in the correlation of the Tertiary lacustrine deposits of the Pacific coast and Great Basin regions.

### REGULAR PROGRAM

*Phosphate deposits of the United States.* F. B. VAN HORN.
There are at present five producing phosphate fields of the United States. In the order of quantity of production they are:

(1) Florida, (2) Tennessee, (3) South Carolina, (4) Arkansas, (5) The Western States—Idaho, Wyoming, and Utah.

In quantity available for the future the most important of these fields is the last named one, where enormous deposits of high grade phosphate rock are available for mining. Tennessee ranks second; Florida third; South Carolina fourth; and Arkansas last.

The Florida deposits are of three classes: hard rock, land pebble, and river pebble, of which the land pebble is of most importance. The Tennessee deposits are also of three classes, according to Hayes; brown residual phosphate, blue bedded phosphate, and white phosphate. The South Carolina phosphate occurs in two forms: hard rock, and river rock. The phosphate of Arkansas occurs in bedded form.

The deposits of the Western States are in northeastern Utah, southwestern Wyoming, and southeastern Idaho. The phosphate horizon consists of 200 feet of phosphatic shales and beds of phosphate rock with some limestone. The rock phosphate itself is chiefly characterized by an oölitic texture, by which it can usually be recognized in the field. In color it varies from coaly black to dull gray or iron stained. Its float is characteristically marked with a thin coating of bluish-white bone-like material, resembling chalcedony, and this coating is useful in tracing the concealed outcrop in the field by means of scattered float or fragments to be found in the overlying soil.

*Asbestos deposits of the United States.* J. S. DILLER. See this Journal, 1: 286. 1911.

*Further data on the stratigraphic position of the Lance formation ("Ceratops beds").* F. H. KNOWLTON.

In June 1909 the author published a paper entitled, "The stratigraphic relations and paleontology of the 'Hell Creek beds,' 'Ceratops beds,' and equivalents, and their reference to the Fort Union formation," in which the conclusion is reached that the beds considered are "stratigraphically, structurally, and paleontologically inseparable from the Fort Union, and are Eocene in age." The present paper presents the results of the two field seasons that have intervened since the first paper was published, the areas in which the observations were made being in the main eastern Wyoming and eastern Montana and adjacent portions of North and South Dakota.

In the early nineties Hatcher discovered dinosaurian remains along the North Platte River some 25 or 30 miles north of old Fort Fred Steele, in Carbon County, Wyoming, the exact locality being indicated as "opposite the mouth of the Medicine Bow River." This area was investigated in 1906 by A. C. Veatch, who published an outline geological map in which was shown the areal distribution of the formations involved. Strictly interpreted Hatcher's locality would fall within Veatch's so-called "Lower Laramie," which is there 6500 feet in thickness, and is separated from the overlying beds (Upper Laramie of Veatch) by an unconformity which according to Veatch has involved the removal of more than 20,000 feet of strata, but as a matter of fact his locality is a mile or more up the North Platte from a point "opposite

the mouth of the Medicine Bow." The author, assisted by Dr. A. C. Peale, visited the area in 1910 and failed to find a trace of remains of dinosaurs in the "Lower Laramie," but did find Triceratops in place 300 feet above the base of the "Upper Laramie," or Lance formation as it must now be called. This discovery is regarded as of far-reaching importance, since it proves that the Lance formation ("Ceratops beds"), which elsewhere rests on Fox Hills and other Montana formations, is here above a great unconformity which separates it from the 6500 feet of "Laramie" and effectually disposes of the contention that the Lance formation is the equivalent of the Laramie.

An area in South Dakota west of the Missouri River and between the Cannonball and Cheyenne Rivers, was studied in 1909 by parties from the U. S. Geological Survey under the general charge of W. R. Calvert, who furnished the data for this part of the paper. The four formations present in this region are Pierre, Fox Hills, Lance and Fort Union. The Fox Hills with a maximum thickness of 150 to 200 feet, has been irregularly reduced by erosion and in exceptional instances has been entirely removed. The Lance formation rests on the eroded surface of the Fox Hills and in at least one locality upon the Pierre. Angular as well as erosional discordance has also been noted between them, especially on the Moreau River near Govert P. O., where the Fox Hills dips at an angle of 10° and the overlying Lance is horizontal. The marine Fox Hills invertebrates, reported at five localities in the basal 10 or 12 feet of the Lance formation, are presumed to be re-deposited, as they always occur in eroded channels.

Converse County, Wyoming, the type locality for the Lance formation, has been visited by several parties and the attempt made to fix the upper line of the Fox Hills, but while it appears that these beds are of unequal thickness, the fact remains that the upper limit is not yet definitely placed.

In southeastern Montana the relations between the Fox Hills and the overlying Lance formation were found to be the same as already shown for South Dakota, that is, they are separated by an unconformity which is erosional and occasionally also angular.

In the original paper the statement was made that thruout the vast region studied the Lance formation was found conformably overlain by the acknowledged Fort Union. Field work of the past two seasons has confirmed this in every particular, and there is yet to be observed a single locality at which unconformable relations have been even suspected. Hence it seems to have been demonstrated that sedimentation from one to the other was continuous and uninterrupted.

The following conclusions regarding the stratigraphic relations of the Lance formation seem justified: (1) The Lance formation is separated from the underlying formations by an unconformity, which in some cases at least is profound; (2) the Lance formation is not the equivalent of the Laramie, in fact, as shown by the relations in Carbon County, Wyoming, they are separated by a great unconformity; (3) the Lance formation cannot be separated on structural or lithologic grounds from

the overlying Fort Union; (4) the line at the base of the Lance formation becomes more clearly than ever the logical point at which to draw the line between Cretaceous and Tertiary; (5) finally, the Lance formation seems to find a final resting place in the Tertiary.

EDSON S. BASTIN,
ROBERT ANDERSON,
*Secretaries.*

## THE PHILOSOPHICAL SOCIETY OF WASHINGTON

At the 697th meeting, held at the Cosmos Club on October 14, 1911, the following papers were read: *Direct and indirect determination of the wilting coefficient of soils for different plants:* L. J. BRIGGS and H. L. SHANTZ. (See this Journal **1**: 228. 1911.) *Magnetic rotation and ellipticity for massive mirrors:* P. D. FOOTE. (See this Journal **1**: 145. 1911.)

The 698th meeting, held on October 28, 1911, at the Cosmos Club, was a joint meeting with the Washington Academy of Sciences. Professor ARTHUR SCHUSTER, by invitation, presented a most interesting and instructive paper on *The foundations of physics.*

At the 699th meeting, November 11, 1911, at the Cosmos Club, the following papers were presented, A. J. LOTKA: *Evolution in discontinuous systems;* P. G. NUTTING: *Helium tubes as light standards.* (See this Journal **1**: 221. 1911.)  R. L. FARIS, *Secretary.*

## THE COLUMBIA HISTORICAL SOCIETY

At the 125th meeting, November 21, 1911, Mrs. CORRA BACON-FOSTER presented a paper on the *Early Development of the Potomac Route to the West.*

MARY STEVENS BEALL, *Secretary.*

## CORRECTIONS, VOL. 1

p. 55, Fig. 1, for "1537° C." read "1357° C."
p. 213, lines 3 and 9, for "(c)" read "(e)."
p. 213, line 15 from bottom, for "one" read "the."
p. 214, line 15, after "force" insert "for unit current in each circle."
p. 216, line 7, before "current," for "the" read "this."
p. 217, line 16, after "called," for "the" read "this."
p. 217, table, for "22° C." read "20° C."
p. 218, line 3, for "$N$" read "$M$."

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